DOCUMENT RESUME

ED 319 911 CE 054 849

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TITLE	Basic Wiring.
INSTITUTION	Mid-America Vocational Curriculum Consortium, Stillwater, Okla.
PUB DATE	88
NOTE	886p.; For related documents, see CE 054 850 and CE 055 217. Printed on colored paper.
AVAILABLE FROM	Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, OK 74074 (order no. CN801301: $22.50).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF06 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Classroom Techniques; Construction (Process); Course Content; Curriculum Guides; Electrical Occupations; Electrical Systems; *Electric Circuits; *Electricity; *Entry Workers; *Job Skills; *Learning Activities; Learning Modules; Lesson Plans; Postsecondary Education; Secondary Education; Skill Development; Teaching Methods; Test Items; Units of Study
IDENTIFIERS	*Electrical Wiring

ABSTRACT

This module is the first in a series of three wiring publications; it serves as the foundation for students enrolled in a wiring program. It is a prerequisite to either "Residential Wiring" or "Commercial and Industrial Wiring." The module contains 16 instructional units that cover the following topics: occupational introduction; general safety; electrical safety; hand tools; specialty tools and equipment; using trade information; basic equipment; basic theory; DC circuits; AC circuits; wiring methods; conductors; low voltage wiring; overcurrent protection; load centers and safety switches; and existing structures. Each instructional unit follows a standard format that includes some or all of these eight basic components: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to tests and assignment sheets. All of the unit components focus on measurable and observable learning outcomes and are designed for use for more than one lesson or class period. Instructional task analyses; a glossary; a list of tools, equipment, and materials; and 34 references are provided. (KC)

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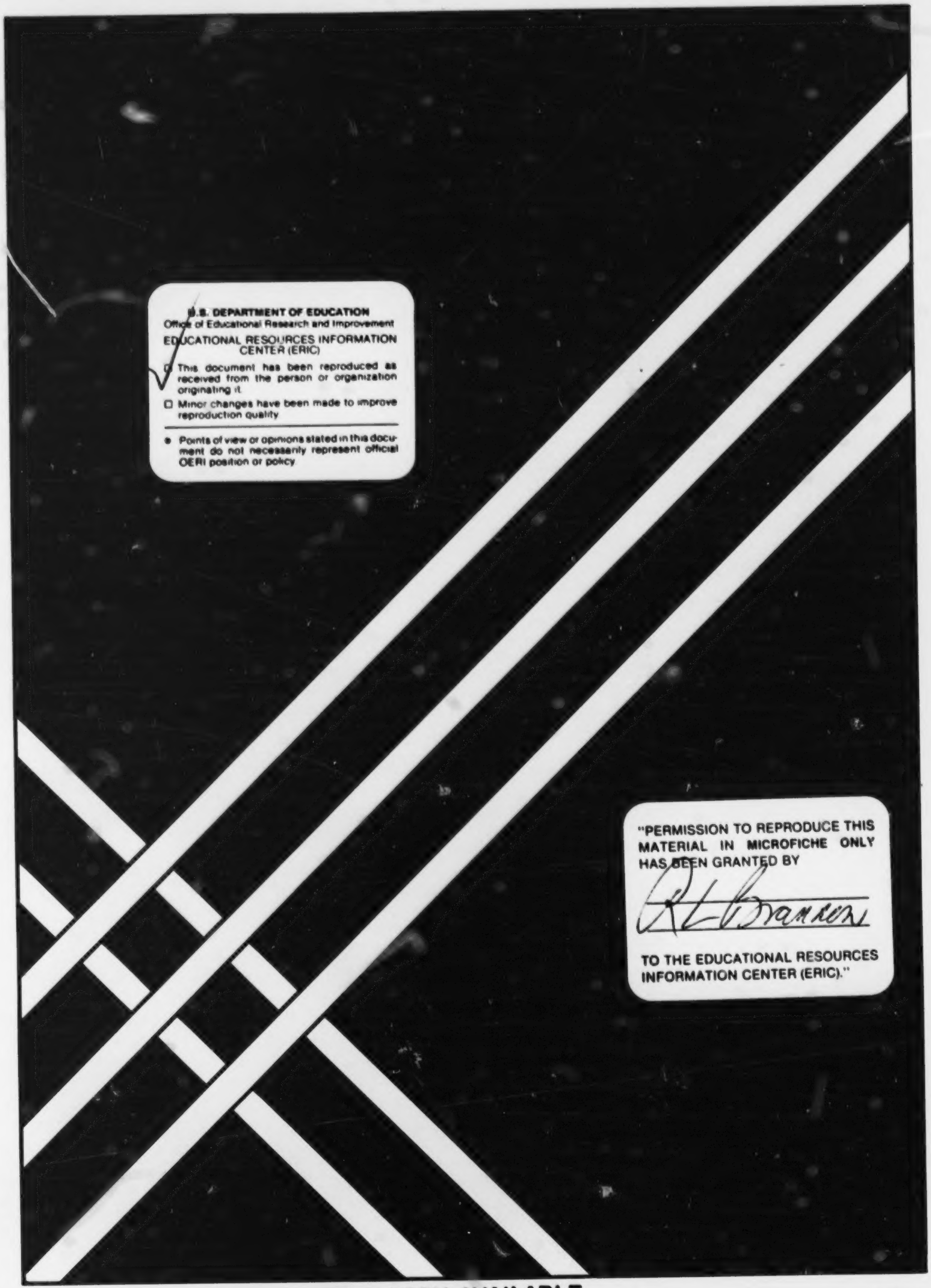

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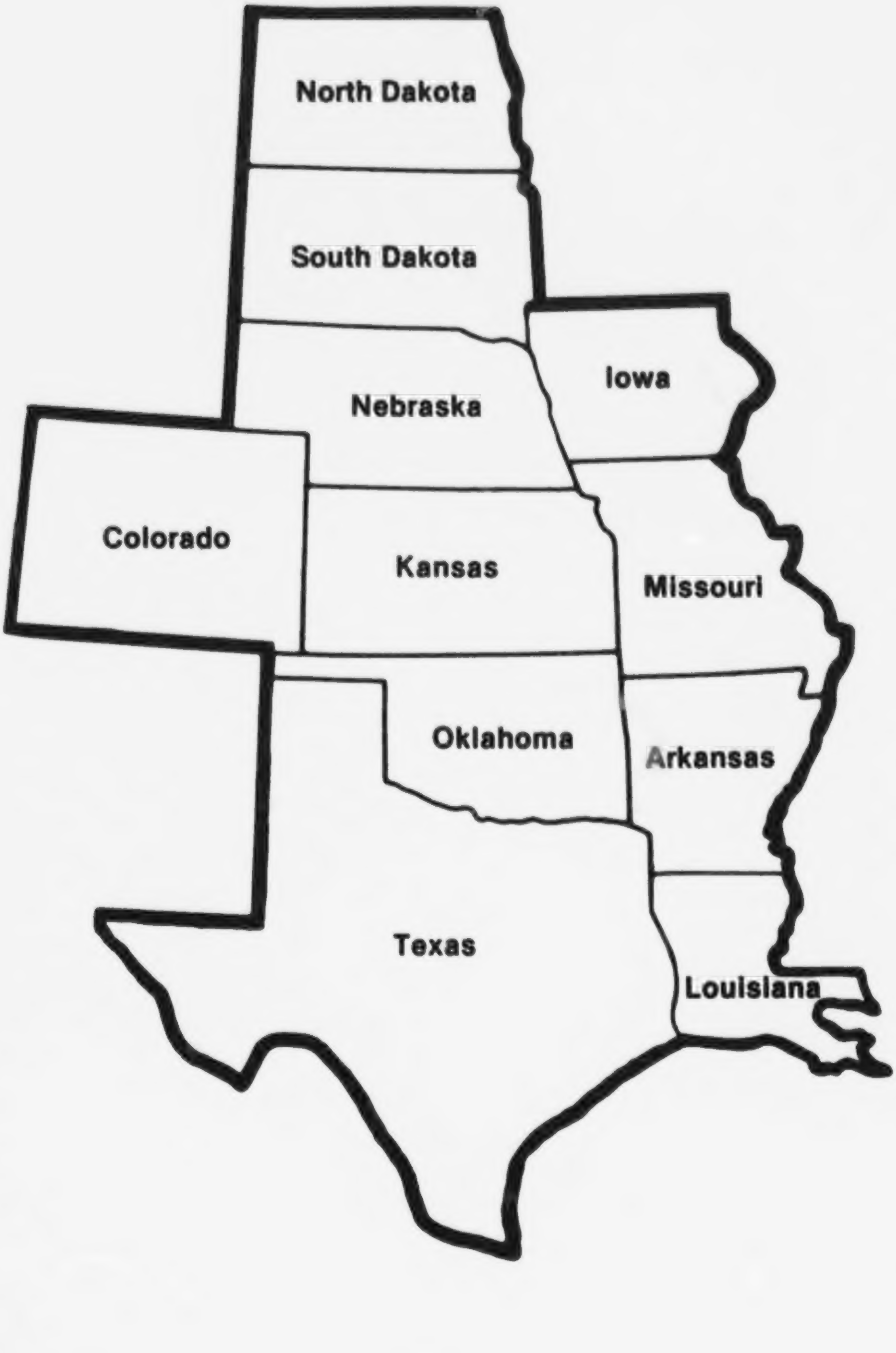
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BASIC WIRING

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Printed in the United States of America by the
Oklahoma State Department of Vocational-Technical Education
Stillwater, OK 74074

Mid-America Vocational Curriculum Consortium, Inc.
1500 West Seventh
Stillwater, Oklahoma 74074-4364

BASIC WIRING

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FOREWORD

Basic Wiring is the first in a series of three wiring publications and serves as the foundation for students enrolled in a wiring program. It is a prerequisite to either *Residential Wiring* or *Commercial and Industrial Wiring*. This series of publications should provide the flexibility that instructors need to meet the individual needs of their students and the community.

Residential Wiring is a revision of MAVCC's 1983 wiring publication of the same name. This manual picks up where the basic manual ends and prepares the student for entry-level employment in the residential wiring trade.

Commercial and Industrial Wiring includes the additional technical knowledge and applications required for job entry in the commercial and industrial wiring trade.

These publications were developed with the assistance of many individuals who have expertise in various areas of the wiring trade. Some of these individuals represent professional associations and industry. Their assistance and devotion to this project is greatly appreciated. It should be emphasized that the student needs to be aware of professional trade associations and take an active part in them as much as possible. The professional trade associations, as well as vocational education, are an excellent avenue for continuing education within the electrical trade.

Every effort has been made to make these publications basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from these publications: motivation, personalization, and localization. Those areas are left to the individual instructors and the instructors should capitalize on them. As these publications are used, it is hoped that students performance will improve and that students will be better able to assume a role in electrical wiring.

Harley Schlichting, Chairman
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ACKNOWLEDGEMENTS

Appreciation is extended to those individuals who contributed their time and talent to the development of *Basic Wiring*.

The contents of this publication were planned and reviewed by:

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Harold Brown	Hope, Arkansas
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Clifford Schaefer	Ft. Worth, Texas
Randy Wilson	Stillwater, Oklahoma

A special thank you goes to the following for granting MAVCC permission to reprint certain graphic materials that enhance this text: Jim Johnson, Telemecanique, Inc.; Marc McCord, Advance Transformer Company; John Henry, Challenger Electrical Equipment Corporation; ERICO Products, Inc.; American Technical Publishers; Bennett Publishing Company; NUS Training Corporation; General Electric Company; and the American Association of Vocational Instructional Materials.

Appreciation is also extended to the artists of the Graphics Division, Oklahoma State Department of Vocational-Technical Education, for their hard work with this project and to members of the Oklahoma State Vo-Tech Print Shop for their excellent service in printing the text.

The text was phototypeset in the Oklahoma State Vo-Tech Communications Center, and for her excellent contribution, a thank you goes to phototypesetter Stephanie Smola.

Thanks are also extended to Jane Huston, coordinator and editor of this project.

USE OF THIS PUBLICATION

Instructional Units

Basic Wiring contains sixteen units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction; performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated

    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations

C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

BASIC WIRING

INSTRUCTIONAL TASK ANALYSIS

UNIT I: OCCUPATIONAL INTRODUCTION

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Importance of the NEC
	3. Job responsibilities of electrical workers
	4. Desirable physical abilities of electrical workers
	5. Employment opportunities in the electrical field
	6. Occupational hazards related to electrical work
7. Interview an electrical worker	
8. Compare employment opportunities in the electrical field	

UNIT II: GENERAL SAFETY

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Personal safety rules
	3. General safety rules
	4. Shop conditions that should be reported
	5. Things OSHA expects of an employer
	6. Things OSHA expects of an employee
	7. Colors of the safety color code
	8. Color coding of the safety tags or signs
	9. Components of the fire triangle

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	10. Types of fires
	11. Types of fire extinguishers
	12. Factors contributing to back injuries
	13. Steps in lifting safely
	14. Safety practices for step ladders and extension ladders
	15. Safety practices for scaffolds
	16. Safety practices for power lifts
	17. Hazardous cleaners and lubricants
	18. Storage of hazardous materials
	19. Hazardous materials that may be found at the job site
	20. General guidelines for first aid emergencies
	21. First aid for eye injuries
22. Complete a student safety pledge form	
23. Identify and correct safety violations	
24. Draw a layout of your school shop and apply safety color code	

UNIT III: ELECTRICAL SAFETY

	1. Terms and definitions
	2. Major causes of electrical accidents
	3. Basic electrical safety practices
	4. Electrical fire prevention practices
	5. Safety practices around live circuits
	6. Proper grounding

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	7. Importance of the third wire
	8. Ground fault interrupters
	9. Uses for lockout devices
	10. Facts about electrical shock
	11. Treating a victim of electrical shock
12. Complete an electrical safety checklist	
13. Solve problems concerning electrical safety practices	

UNIT IV: HAND TOOLS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Common hand tools
	3. Electricity-specific hand tools
	4. Uses of common hand tools
	5. Uses of electricity-specific hand tools
	6. Factors to consider when purchasing hand tools
	7. Rules for care of various hand tools
8. Clean and lubricate an adjustable hand tool	
9. Use a cutting-crimping tool	
10. Adjust wire strippers	
11. Set up and use a hack saw	
12. Cut rigid conduit with a pipe cutter	
13. Ream rigid conduit	
14. Bend EMT conduit	
15. Use a knockout punch	
16. Use a hole saw	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT V: SPECIALTY TOOLS AND EQUIPMENT	
	1. Terms and definitions
	2. Typical power equipment
	3. General safety rules for using power equipment
	4. Parts of a hydraulic knockout set
	5. Specific safety rules for using hydraulic knockout sets
	6. Parts of a hydraulic pipe bender
	7. Safety rules for using hydraulic pipe benders
	8. Parts of an electrical polyvinyl chloride (PVC) heater
	9. Specific safety rules for using electric polyvinyl chloride (PVC) heaters
	10. Parts of a power drill
	11. Specific safety rules for using power drills
	12. Parts of a power threader
	13. Specific safety rules for using power threaders
	14. Typical rules and scales
	15. Typical test equipment
16. Measure objects using a rule	
17. Determine lengths of lines using an architect's scale	
18. Use a hydraulic knockout punch	
19. Bend a 90-degree stub using a hydraulic pipe bender	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
20. Make offset and 90-degree bends using an electric PVC heater	
21. Cut, ream, and thread rigid conduit with a power threader	
22. Measure resistance using a VOM	
23. Measure DC voltages using a VOM	
24. Measure AC voltages using a VOM	
25. Measure amperage using a clamp-on ammeter	
26. Determine the current of a multiple-loop clamp-on ammeter	
27. Check conductor insulation with a megger	

UNIT VI: USING TRADE INFORMATION

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Purpose of the National Electrical Code
	3. Factors that are not covered by the NEC
	4. Intent of the NEC regarding mandatory enforcement
	5. NEC chapter numbers and their areas of application
	6. Sequence of organizational components of NEC information
	7. Steps for finding information in the NEC
8. Use the National Electrical Code (NEC) index	
9. Use the National Electrical Code (NEC) introduction and first chapter	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
10. Answer questions related to residential wiring practices using the NEC as a reference	
11. Locate allowable ampacities for various conductors using the NEC as a reference	
12. Interpret conduit fill tables using the NEC as a reference	
13. Find information in the NEC	

UNIT VII: BASIC EQUIPMENT

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Classes of outlet boxes
	3. Information needed to calculate boxfill
	4. Types of enclosures
	5. Purposes of controller enclosures
	6. Types of devices
	7. Types of covers and plates
	8. Supports and anchors commonly used in electrical wiring
	9. Screws, bolts, and nuts commonly used in electrical wiring
	10. Classes of box mounting devices for steel structures
11. Determine the correct number of conductors for boxfill	
12. Install outlet boxes on wood studs on a framed wall	
13. Install outlet boxes on steel structures and rods using caddy clips	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

14. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes

15. Install masonry boxes in a block wall

UNIT VIII: BASIC THEORY

1. Terms and definitions
2. Principles of electron flow
3. Basic sources of generation
4. Distribution of electricity
5. Electrical schematic symbols
6. Diagrams and schematics
7. Letters and their terms
8. Ohm's law
9. Ohm's law in wheel expression
10. Uses of Ohm's law
11. Formulas from Ohm's law
12. Ohm's law for power
13. Ohm's law for power in wheel expression
14. Uses of Ohm's law for power
15. Formulas from Ohm's law for power

16. Draw a diagram of the power distribution supplying your school shop

17. Solve problems for an unknown voltage

18. Solve problems for an unknown amperage

19. Solve problems for unknown resistance and wattages

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT IX: DC CIRCUITS

1. Terms and definitions
2. Applications of DC circuits
3. Application of Ohm's law to DC
4. Characteristics of series circuits
5. Basic formulas for Watt's law
6. Kirchoff's voltage law
7. Characteristics of parallel circuits
8. Kirchoff's current law
9. Characteristics of series-parallel circuits
10. Facts about magnetism
11. Solve problems for an unknown current
12. Solve problems for an unknown resistance
13. Solve problems for an unknown voltage
14. Determine the total resistance in a series circuit
15. Determine unknown resistor values in a series circuit
16. Solve problems for unknown current in a series circuit
17. Solve problems for unknown resistance in a series circuit
18. Solve problems for unknown voltage in a series circuit

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
19. Apply Kirchoff's voltage law to series circuits	
20. Solve problems for unknown resistance in a parallel circuit	
21. Solve problems for unknown current in a parallel circuit	
22. Apply Kirchoff's current law to parallel circuits	
23. Solve problems for unknown resistance in a series-parallel circuit	
24. Solve problems for unknown voltage in a series-parallel circuit	
25. Solve problems for unknown current in a series-parallel circuit	
26. Compute power using Ohm's power law	
UNIT X: AC CIRCUITS	
	1. Terms and definitions
	2. Principles of AC theory
	3. Principles of induction
	4. Characteristics of inductance
	5. Factors affecting inductors
	6. Power characteristics in an inductive circuit
	7. Characteristics of a transformer
	8. Classes of transformers
	9. Transformer connections on a three-phase delta system
	10. Transformer connections found in electrical trades

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	11. Power in three-phase circuits
	12. Testing for polarity
	13. Characteristics of capacitance
	14. Types, ratings, and common defects of capacitors
	15. Characteristics of impedance in RC circuits
	16. Characteristics of impedance in RL circuits
	17. Characteristics of power in an AC circuit
	18. Basic switching circuits used in electricity
19. Solve power factor problems	
20. Solve RC and RL circuit problems	
21. Draw a diagram of a single pole switch on a light	
22. Draw a diagram of two three-way switches on a light	
23. Draw a diagram of two three-way switches and a four-way switch on a light	
24. Wire a single pole switch controlling a single lighting outlet with the supply line entering the switch box	
25. Wire a single pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box	
26. Wire a three-way switching situation with the supply entering a single lighting outlet	
27. Wire a four-way switching situation with the supply entering the lighting outlet box	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT XI: WIRING METHODS	
	1. Terms and definitions
	2. Wiring methods found in electrical trades
	3. Wiring methods and their common applications
4. Reference the National Electrical Code to identify uses of wiring methods	
5. Install a set screw conduit fitting	
6. Install a compression type conduit fitting	
7. Braid the ground conductor of a service entrance cable	
8. Install an ENT coupling and connector on ENT conduit	
UNIT XII: CONDUCTORS	
	1. Terms and definitions
	2. Factors that determine type and size of conductors
	3. Characteristics of good connections
	4. Types of connectors, terminals, and lugs
	5. Types of insulation
	6. Conductors commonly found in electrical wiring
	7. Types of cable found in the electrical field
	8. Cords and their conductors
	9. Cables and their conductors

JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)

RELATED INFORMATION: What
the Worker Should Know
(Cognitive)

10. Select conductors for various ampacities and temperatures
11. Calculate ampacity of conductors, given number of conductors in raceway
12. Calculate ampacity and conductor sizes
13. Select cords for various applications
14. Select proper types of insulation
15. Install cord on utilization equipment
16. Use a fish tape to install wire in conduit
17. Prepare an aluminum conductor for termination

UNIT XIII: LOW VOLTAGE WIRING

1. Terms and definitions
2. Parts of a low voltage wiring system
3. Low voltage lighting circuit off/on cycle
4. Energizing of a chime circuit
5. Manual fan switching circuit
6. Thermostat system switch in cool position, fan switch on auto
7. System switch in heat position
8. Anticipator circuits on low voltage thermostats
9. Communication circuits and their characteristics
10. Smoke and fire alarm systems
11. Operation of a garage door opener

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
12. Draw a wiring diagram indicating the proper connection for bell circuit equipment	
13. Wire a two switch low voltage lighting circuit	
14. Wire a two button chime circuit	
15. Determine heat anticipator current draw	
16. Install a wall thermostat	

UNIT XIV: OVERCURRENT PROTECTION

	1. Terms and definitions
	2. Types of overcurrent protective devices
	3. Operation of a single element fuse
	4. Operation of a dual element time delay fuse
	5. Types of circuit breakers
	6. Requirements for fuses of less than 600 volts
	7. Requirements for circuit breakers of less than 600 volts
	8. Installations that require GFCI protection
9. Calculate fuse sizes	
10. Test cartridge fuses	

UNIT XV: LOAD CENTERS AND SAFETY SWITCHES

	1. Terms and definitions
	2. Types of safety switch enclosures
	3. Safety switch system configurations
	4. Types of load centers and enclosures

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	5. Common load center accessories
	6. Parts of a fusible load center
	7. Parts of a breaker load center
	8. Common panel bus configurations
	9. Safety rules for working around load centers and safety switches
10. Using the NEC, answer questions related to load centers	
11. Install a safety switch	
12. Wire a load center or breaker panel	
13. Wire a receptacle circuit to a load center	

UNIT XVI: EXISTING STRUCTURES

	1. Terms and definitions
	2. Construction members common in existing structures
	3. Common routes for new cable installations in existing structures
	4. Possible methods for getting cable through or around construction members
	5. Wall or ceiling composition
	6. Optional calculation for additional loads to existing installations
	7. Exceptions to the NEC requirements for support of flexible metal conduit
	8. Steps for determining the number of conductors allowed in a conduit, based on cross sectional area

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
9. Determine the number of conductors allowed to be added to an existing conduit	
10. Install a box with dry wall grips in a plasterboard wall	
11. Secure a box with dry wall supports (box tins)	
12. Install a box in a lath and plaster wall	
13. Install a box in a paneled wall	
14. Install a box in a concrete block wall	

BASIC WIRING

GLOSSARY

A

Accident — Any suddenly occurring, unintentional event which causes injury or property damage

Accuracy — How near the instrument reading is to the actual value

Air circuit breaker — Breaker in which all parts operate in air

Aluminum wire — Conductor made of aluminum

American National Standards Institute (ANSI) — Develops standards for electrical equipment and supplies

American Standard Association (ASA) — Develops standards for electrical machinery and equipment

Ampacity — The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

Amperage — Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

Amperage rating — Maximum current-carrying capacity of a device

Ampere — A measure of the intensity of electron flow

Apparent power — Term used to describe the power which "appears" to be consumed in an RC circuit when the power formula P = IE is applied to the circuit

Arbor — Shaft or spindle used to hold revolving cutting tool or the work to be cut

Autotransformer — Transformer with a single winding

AWG — American Wire Gauge

B

Bare conductor — A conductor having no covering or electrical insulation

Bender — Tool used to make various angles or bends in conduit

Blade type cartridge fuse — Fuse with flat contact blades on a cylindrical case

Bonding — Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

Bonding jumpers — Pieces of wire or other conductors that connect different metal parts

Bonding jumper circuit — Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

Bonding jumper equipment — Connections between two or more portions of the equipment grounding conductors

Boxfill — Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

Brick bat — Piece of a brick

Building code — Standards developed to provide for safe building construction practices

C

Cabinet — Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

Cable — A factory assembly of two or more insulated and uninsulated conductors having an outer sheath of moisture-resistant, flame-retardant, non-metallic material

Cable-tie — Plastic straps with pull-through fasteners for binding together conductors or cables

Calibration — Technique of testing and adjusting an instrument by referencing it to another instrument or device of known accuracy and precision

Cardiopulmonary resuscitation (CPR) — Emergency procedure performed by trained individuals to aid a heart attack victim

Channel — Groove formed in materials

Chuck — Device for holding a component of a tool rigid

Circuit — A complete path for current to flow from the source through the load and back to the source

Circuit box — Box where electrical connections are made, usually through circuit breakers

Circuit breaker — Automatic overcurrent device that trips on overloads or shorts and is resettable

Circular mils — The diameter of a conductor in thousandths of inches multiplied times itself

Coaxial cable — Conductor used for carrying communication signals

Color coding — Assigning colors to conductors based on their uses

Combustibles — Materials or liquids that catch fire easily

Concentric knockout — Several removable metal rings that allow for entrance of various standard sizes of connectors into a cabinet

Conductor — Material through which electrons flow easily; used to connect components

Conduit — Pipe or tube which holds and protects wires or cables

Connections — Termination points where conductors are joined together

Copper-clad aluminum — Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

Copper wire — Conductor made of copper

Cord — Two or more stranded conductors grouped together in a flexible covering

Coupling — Mechanical device for connecting conduit and cabling

Covered — Conductor encased within material of composition and thickness not recognized by the *National Electrical Code* as electrical insulation

Cross handle — Handle set across a power tool to prevent the tool from turning

Cross sectional area — Area in square inches allowed in a conduit or tubing; area required for conductors in a conduit or tubing

Cube tap — A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

Current-limiting overcurrent protective device — Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

Cutter — Hardened steel device used to cut holes in metal boxes

D

DC — Abbreviation for direct current

Dead front — Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment

Device — Electrical equipment that carries or transfers current but does not use it

Die — Component that backs up cutter on opposite side of metal box

Dielectric materials — Insulating materials capable of accumulating an electrical charge

Disconnecting means — Device or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

Domains — Molecules that act as small magnets when arranged end to end

Drop cloth — Cloth used to catch falling debris from cutting or chipping work

Drop chain — Short length of small chain used to pull cable or flexible conduit through an enclosed space or wall cavity

Dual-element fuse — Fuse that has a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without having the fuse

Dustproof — So constructed or protected that dust will not interfere with successful operation

Dusttight — So constructed that dust will not enter the enclosing case

E

Eccentric knockout — Knockout that is removed in sections to form larger holes

Edison base plug fuse — Fuse with a base that fits the same sockets as a regular based incandescent bulb

Electricity — Invisible energy

Electromagnet — A magnet made by winding a conductor around a metal core with voltage applied

Electron flow — When electrons are transferred from one atom to another

Equipment — A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation

Error — How far the measurement is from the actual value

Explosionproof — Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

Exposed (as applied to wiring methods) — On or attached to the surface or behind panels designed to allow access

F

Fault current — Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

Ferrule type cartridge fuse — Fuse with metal caps on a cylindrical case

Fire extinguisher — That which quickly puts out fires or at least smothers flames

First aid — Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

Fish — Establishing a connection between two points so a cable can be installed

Fish tape — Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

Fish wire — Length of wire with a hook formed in one end to catch materials being installed in a space

Fitting — An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function

Flux lines — Power around a magnet

Formula — A mathematical expression used to find unknowns

Fuse — Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

G

Ground — Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

Grounded — Connected to earth or to some conducting body that serves in place of the earth

Grounded conductor — Intentionally grounded system or circuit conductor (neutral)

Grounding conductor — Conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

Grounding electrode conductor — Conductor used to connect the grounding electrode to the equipment grounding conductor or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system

Ground fault — Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

Ground fault circuit interrupter — Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 amperes

H

Hazard — A potential source of danger

Heat detectors — A fire warning device commonly used in a residence; available in two types; fixed or rate-of-rise temperature detectors

Heat shrink — Nonconductive material placed around a conductor for insulation; shrinks when heated

Henry — Amount of inductance into a conductor when the current changes at the rate of one ampere per second

Hertz — One complete positive to negative cycle in an alternating current circuit

Hydraulic — A system where the main operation of equipment is operated by fluids

Hydraulic oil — Specially formulated oil for hydraulic pumps

I

Insulated — Conductor encased within material of composition and thickness recognized by the *National Electrical Code* as electrical insulation

Insulation — Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

Interrupting rating — Maximum available short-circuit current that an overcurrent device can safely interrupt without danger to itself

J

Joint Industry Conference (JIC) boxes — Boxes or enclosures made to Joint Industry Conference Standards for such uses as junction boxes and housing terminal blocks

Junction boxes — Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

Jurisdiction — Power, right, or authority to interpret the law (code)

K

Knockout (KO) — Partially cut out piece of metal or plastic that can be forced out when a hole is needed

Knockout punch — Device used to make openings for conduit in metal enclosers

L

Lath and plaster — Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

Live circuit — Circuit with voltage applied

M

Magnetism — Property possessed by certain materials which exerts a mechanical force on other magnetic materials, and which can cause induced voltage in conductors when relative movement is present

Mandatory enforcement — Governmental authority to demand compliance with the National Electrical Code requirements for electrical installations

Mil — One thousandth of an inch

32

Momentary contact switch — A switch that is closed or opened only while the operator touches it

Multimeter — Instrument capable of measuring a "mulitiple" of values

Multi-outlet assembly — A type of surface of flush raceway designed to hold conductors and receptacles

N

National Electrical Code (NEC) — A publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity

National Electrical Manufacturers Association (NEMA) — Develops electrical equipment standards

National Fire Protection Association (NFPA) — Develops and publishes fire and industrial safety standards

NEMA Type 1 — General purpose enclosure for use indoors under usual service conditions

NEMA Type 2 — Driptight enclosure used indoors to exclude falling moisture and dirt

NEMA Type 3 — Weather resistant (weatherproof) and suitable for indoor and outdoor use; will exclude falling dirt, light liquid splashing, rain, snow, sleet, and windblown dust

NEMA Type 4 — Watertight and dustproof enclosures suitable for areas where a great amount of splashing occurs, such as hose down area

NEMA Type 5 — Dust-tight enclosure not suitable for use around water

NEMA Type 12 — Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

NEMA enclosures — Electrical enclosures specifically designed to standards for use in specific locations and various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

O

Occupation — The vocation or activity at which a person works

Occupational Safety and Health Administration (OSHA) — Federal legislation designed to insure safe and sanitary working conditions for employees

Ohm — Unit of measure for the opposition to electron flow in a circuit

Oil circuit breaker — Load interrupter in which the interrupting contacts operate submerged in transformer oil

Opposition — A resistance to current flow

Outlet boxes — Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

Overcurrent protection — Weak link in the circuit that limits the amperage to a specified amount

Overload — Larger than normal current flowing within the normal current path

P

Parallax correction — Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

Parallel circuit — A circuit which provides more than one path for current to flow

Pinch point — Any opening that may close and bind a finger or hand

Pipe chase — Usually a vertical space between two floors, dedicated for the running of pipes and conduits between floors

Plasterboard — Thin board formed of layers of plaster and paper; Sheetrock

Pneumatics — A system where the main operation of equipment is operated by air

Polarity — When magnetism leaves a body north and enters south

Polyvinyl chloride (PVC) — Plastic pipe

Power — Rate of consumption of energy

Precision — Instrument consistency

Premises wiring (system) — That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment

Primary — Where voltage enters a transformer

Print — Industrial blueprint; industrial wiring diagram

Pull-push solenoid — Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has current applied to it

R

Rainproof — So constructed, protected, or treated as to prevent rain from interfering with successful operation

Raintight — So constructed or protected that exposure to a beating rain will not result in the entrance of water

Ram — Device used to transfer hydraulic pressure to a mechanical device

Relay — Electromagnetic device for remote or automatic control

Resistance — Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

Resolution — How well an instrument will indicate a small change in the measured value

S

Safety — State or condition of being safe; freedom from danger, risk, or injury

Secondary — Where voltage leaves a transformer

Selective coordination — The use of interrupting devices sized and installed so that the one nearest a fault or overload will open before any of the larger upstream devices open

Series circuit — A circuit where the same current passes through each component

Series-parallel circuit — A circuit that contains some components in series and some in parallel

Shock — The sudden stimulation of the nerves and muscles caused by the discharge of electricity through the body; shock can occur if the body contacts an electrical circuit and can cause serious burns and muscle damage

Short circuit — Larger than normal current flowing outside the normal current path

Single element fuse — Fuse that contains only one element and is not designed to carry an overload

Single phase — One power source

Smoke detector — A fire warning device commonly used in a residence that is available in two types: photoelectric or ionization

Snap ring — Metal ring which fastens around or in a shaft to keep other parts stationary

Solenoid — Electromagnetic cylinder that will move an iron plunger when current is applied

Spaghetti — Nonconductive material placed around a conductor for insulation; does not shrink

Stud finder — Compass type tool which uses a magnet to locate nails and thus indicate stud locations

T

Telephone system — A personal communication system installed in the home to provide outside conversation with the world

Thermostat — A device that senses temperature variations from a set point and, in turn, acts to control a circuit

Time current curve — Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

Transformer — An electrical device used to step up or step down a primary voltage to a desired secondary voltage

True power — The power that a device is actually using

Type letter — Identification accepted by the trade in referring to the particular types of insulations

Type "S" plug fuse — Fuse with special size limiting characteristics for each amperage range

U

Underfloor crawl space — Working space underneath the house

Underwriters Laboratories (UL) — Test equipment and list items for use in specified situation

V

Volt — Unit of measure of electromotive force or potential difference

Voltage — Electromotive force (emf); force that drives electricity through conductors; must be measured across, between, or be referenced to a second point

Voltage drop — Reduction in circuit potential difference due to resistance

Voltage rating — Maximum voltage at which a device is designed to operate

W

Watt — Unit of measure for the power of an electric circuit

Waveform — The shape of a wave as a function of time, distance, and amplitude

Windings — Conductors coiled around a metal core in a transformer or motor

Wire lug — Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

BASIC WIRING

TOOLS, EQUIPMENT, AND MATERIALS LIST

A

- Adjustable wire strippers
- Adjustable wrench
- Ammeter
- Anchors
- Antioxidant
- Arbor

B

- Bar hanger
- Battery
- Bolts
- Box clips
- Breaker index sheet
- Breakers
- Brick wall

C

- Cable clamp, 3/8″
- Carriage lever accessory
- Clamp-on ammeter
- Cleaning cloth
- Compression type fitting, 1/2″
- Concrete chisel
- Conduit bender
- Connectors
- Copper wire
- Cord connector
- Couplings
- Cutting/crimping tool
- Cutting oil

D

- Device box
- Die head accessory
- Door bell buttons
- Drill
- Drill bit
- Drill motor
- Drop chain
- Drop cloth
- Drop light and cord
- Duplex receptacle
- Dust mask

E

- Electrician's knife
- EMT bender, 1/2″
- Extension cord

F

- Fish tape, steel
- Fixed appliance, small
- Fuses

H

- Hacksaw
- Hacksaw blade
- Hammer
- Hanger bar
- Header board
- Heating unit
- Hole saw
- Hook knife
- Hydraulic pipe bender

I

- Incandescent bulb, 120V

K

- Keyhole saw
- Knockout punch

L

Ladder
Level
Lighting relay
Light socket
Live disconnect

M

Masking tape
Megger
Mortar
Multimeter

N

Nails
Needlenose pliers
NM cable

O

Octagon box
Oil
Oiler
Outlet boxes

P

Pail
Paneled wall
Pencil
16 penny nails
Phasing tape
Pipe or conduit
Pipe cutter
Pipe reamer
Pipe vise
Plasterboard
Plasterboard nails
Plaster rings
Pliers
Pouch tools
Power threader, stand
Protective gloves
PVC conduit
PVC glue
PVC heater

R

Reamer
Resistor
Rigid conduit
Romex staples

S

Safety glasses
Safety switch
SE cable
Set screw fitting, ½"
Shop towel
Single pole switch
Solid insulated conductor
Solvent
Solvent tray
Sponge
Square boxes
Staples
Steel pipe
Stepladder
Stud clips
Stud wall
Switch, 3-way
Switch, 4-way

T

Test leads
Thermostat
Thermostat subbase
Tool carriage accessory

V

Vise
Volt-ohmmeter

W

Whisk broom
Wire, #10 THHN
Wire brush
Wire connectors
Wire lug
Wire nuts
Work board

BASIC WIRING

REFERENCES

ABC's of Fire Protection. Belleville, New Jersey: Walter Kidde & Co., Inc., 1978.

Adams, James E. and Gordon Rockmaker. *Industrial Electricity Principles and Practices.* Third Edition. New York: McGraw-Hill Book Co., 1985.

American Red Cross: Adult CPR. American National Red Cross, 1987.

Basic Electricity Review. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

Buss Full Line Catalog (FLC). Bussman Division, McGraw-Edison Co., 1985.

Cildera, Robert and Kenneth Sharpe. *Construction Wiring.* Albany, NY: Delmar Publishers, 1982.

DC Fundamentals Review. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1981.

Digest. Park Ridge, IL: Square D Company, 1987.

Electricity Occupations Curriculum Guide. Springfield, IL: Illinois Office of Education — Division of Vocational and Technical Education, 1975.

Electromagnetic Induction Review. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

Foley, Joseph H. *Electrical Wiring Fundamentals.* New York: Gregg, McGraw-Hill Book Company, 1981.

Hartman, Lonnie. *Basic Electronics.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

Holub Catalog No. 23, ITT Holub Industries, Sycamore, Illinois.

Holzman, Harvey N. Modern Residential Wiring. South Holland, IL: Goodheart-Wilcox Company, Inc., 1986.

Hunzicker Brothers Catalog, 501 N. Virginia, Oklahoma City, OK 73125.

Industrial Control Catalog, 1986-87. Milwaukee, WI: Cutler-Hammer Products, 1986.

Klein Tools Catalog. Klein Tools, Inc., 7200 McCormick Blvd., Chicago, IL 60645. PH: (312) 677-9500.

Kubala, Thomas S. *Electricity 1: Devices, Circuits, and Materials*. Fourth Edition. Albany, NY: Delmar Publishers, Inc., 1986.

Leviton Catalog D-100, Leviton Manufacturing Co., Brooklyn, New York.

Maintenance of Low Voltage Circuit Breakers and Switch Gear. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1981.

Miller, Rex. *Industrial Electricity*. Peoria, IL: Bennett Publishing Company, 1982.

Mullin, Ray C. *Electrical Wiring: Residential*. Eighth Edition. Albany, NY: Delmar Publishers, Inc., 1984.

National Electrical Code, 1987. Quincy, MA: National Fire Protection Association, 1986.

OSHA Safety and Health Standards. Washington, D.C. 20402: U.S. Department of Labor, Occupational Safety and Health Administration.

Roco Steel Box Catalog No. B-774, Roco Inc., South Bend, Indiana.

Safety in Electrical Maintenance. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

Schram, Peter J. *The National Electrical Code Handbook, 1987*. Quincy, MA: National Fire Protection Association, 1986.

Siebert, Leo N. *Introduction to Industrial Electricity-Electronics*. Stillwater, OK: Curriculum and Instructional Materials Center, 1981.

Stallcup, James G. *Illustrated Changes of the 1987 NEC*. Homewood, IL: American Technical Publishers, Inc., 1986.

Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

The American Red Cross, Standard First Aid and Personal Safety. Garden City, NY: Doubleday and Co., Inc., 1978.

Turner, J. Howard. *Understanding Electricity and Electrical Terms*. Athens, GA: American Association for Vocational Instructional Materials, 1974.

Using Electrical Test Equipment. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

OCCUPATIONAL INTRODUCTION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the occupational outlook of the electrical field as well as the hazards involved and the working conditions. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define NEC and occupation.
2. State the importance of the NEC.
3. List job responsibilities of electrical workers.
4. Select from a list desirable physical abilities of electrical workers.
5. List eight employment opportunities in the electrical field.
6. List four occupational hazards related to electrical work.
7. Interview an electrical worker. (Assignment Sheet #1)
8. Compare employment opportunities in the electrical field. (Assignment Sheet #2)

OCCUPATIONAL INTRODUCTION
UNIT I

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Provide students with objective sheet.

C. Discuss unit and specific objectives.

D. Provide students with information and assignment sheets.

E. Discuss information and assignment sheets.

F. Integrate the following activities throughout the teaching of this unit:

1. Invite local contractors, electricians, and inspectors to class to discuss employment opportunities and their respective job responsibilities.
2. Visit local electrical construction sites.
3. Visit a local manufacturer that employs electrical maintenance workers.
4. Upon completion of Assignment Sheet #1, have students share the information they obtained during their interviews with electrical workers.
5. Upon completion of Assignment Sheet #2, have students compare employment opportunities and compile a list of local employment opportunities.
6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

G. Give test.

H. Evaluate test.

I. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *Electricity Occupations Curriculum Guide*. Springfield, IL: Illinois Office of Education-Division of Vocational and Technical Education, 1975.

B. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

OCCUPATIONAL INTRODUCTION
UNIT I

INFORMATION SHEET

I. **Terms and definitions**

A. National Electrical Code (NEC) — A publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity

(NOTE: The National Electrical Code is updated every three years.)

B. Occupation — The vocation or activity at which a person works

II. **Importance of the NEC**

A. The NEC sets the minimum standards for electrical work in general and specific instances.

B. Any person employed in the electrical field should obtain a copy of the NEC and know how to use it.

(NOTE: This is commonly referred to as the electrician's bible.)

III. **Job responsibilities of electrical workers**

(NOTE: The student entering the electrical field should be aware of the need for continued study. As industry changes, new methods and techniques will become industry standards. If you allow yourself to fall behind the emerging technology, your job may become obsolete. Electrical workers are expected to use and interpret the National Electrical Code as well as perform complex mathematical calculations.)

A. Install all types of electrical equipment.

B. Hang electrical fixtures.

C. Install switching and power outlets.

D. Install appliances.

E. Design electrical systems.

F. Troubleshoot and repair defective systems.

G. Practice good work ethic. Be dependable and honest.

H. Be courteous to customers and co-workers.

I. Communicate effectively with people.

J. Practice good personal hygiene.

K. Participate in trade organizations.

EXAMPLES: IBEW, AIECA, AGC, NECA

INFORMATION SHEET

IV. **Desirable physical abilities of electrical workers**

A. Ability to distinguish colors

(NOTE: Many components and conductors commonly used in the electrical field are color coded. It is imperative that workers are able to distinguish colors readily.)

B. Ability to lift heavy objects

C. Ability to work in confined areas such as crawl spaces and attics

D. Ability to work on ladders and scaffolds

E. Ability to work with hands in a skillful manner

V. **Employment opportunities in the electrical field**

A. Electrician's helper — One who assists an electrician

B. Installer — Installs electrical equipment under the supervision of a journeyman

C. Apprentice — A helper with two years of experience

D. Journeyman — Electrician working under the supervision of a contractor

E. Master electrician or contractor — Licensed to enter contractual agreements involving electrical work

F. Maintenance electrician — Maintains and repairs electrical equipment and processes

G. Electrical parts/equipment salesperson — Works for electrical wholesale parts outlet

H. Inspector — Represents authority having jurisdiction over electrical installations

VI. **Occupational hazards related to electrical work**

(NOTE: The electrical worker is a highly respected trade worker. The jobs that are performed are generally in the areas or surroundings more desirable than other trades. However, conditions do occur that are more demanding or are in areas that are more difficult to work in such as crawl spaces and high places. Inclement weather is also a factor.)

A. Death — Careless and unsafe work habits can result in fatal accidents

B. Burns — Accidental shorts or faults occasionally blow slag or molten metal which can burn

C. Broken bones or bruises — Working on ladders or in other hazardous construction situations can result in falls

D. Sprains or muscle tear — Many pieces of electrical equipment are heavy and bulky, and help must be summoned often to avoid injury to one person.

OCCUPATIONAL INTRODUCTION
UNIT I

ASSIGNMENT SHEET #1 — INTERVIEW AN ELECTRICAL WORKER

NAME ______________________________ SCORE ____________

Directions: Locate and interview an electrical worker in your area. Answer the following questions based on your interview. Be prepared to discuss the interview in class.

1. What is the occupation of the worker being interviewed and what are the job responsibilities?

2. What type of training is needed? ____________

3. What kind of salary can be expected? ____________

4. What is the future outlook for this occupation? ____________

OCCUPATIONAL INTRODUCTION
UNIT I

ASSIGNMENT SHEET #2 — COMPARE EMPLOYMENT OPPORTUNITIES IN THE ELECTRICAL FIELD

NAME ______________________________ SCORE ______________

Directions: Collect four classified advertisements from your local or area newspaper relating to employment opportunities in the electrical field. Compare each opportunity and determine which one would best suit your interests and needs. Write a paragraph on why you chose that occupation and be able to discuss in class.

OCCUPATIONAL INTRODUCTION
UNIT I

TEST

NAME ______________________ SCORE ____________

1. Define NEC and occupation.

   a. NEC — ______________________

   b. Occupation — ______________________

2. State the importance of the NEC.

3. List six job responsibilities of electrical workers.

   a. ______________________

   b. ______________________

   c. ______________________

   d. ______________________

   e. ______________________

   f. ______________________

TEST

4. Select from the following list desirable physical abilities of electrical workers by placing an "X" in the blanks preceding the correct statements.

   _____a. Ability to lift at least 250 lbs.

   _____b. Ability to work with hands in a skillful manner

   _____c. Ability to see perfectly

   _____d. Ability to distinguish colors

   _____e. Ability to work in confined areas such as crawl spaces and attics

   _____f. Ability to work on ladders and scaffolds

5. List eight employment opportunities in the electrical field.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

   g. ______________________________

   h. ______________________________

6. List four occupational hazards related to electrical work.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

7. Interview an electrical worker. (Assignment Sheet #1)

8. Compare employment opportunities in the electrical field. (Assignment Sheet #2)

OCCUPATIONAL INTRODUCTION
UNIT I

ANSWERS TO TEST

1. a. NEC — National Electrical Code; a publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity
   b. Occupation — The vocation or activity at which a person works

2. The NEC sets the minimum standards for electrical work in general and specific instances; any person employed in the electrical field should know how to use it.

3. Any six of the following:

   a. Install all types of electrical equipment.
   b. Hang electrical fixtures.
   c. Install switching and power outlets.
   d. Install appliances.
   e. Design electrical systems.
   f. Troubleshoot and repair defective systems.
   g. Practice good work ethic. Be dependable and honest.
   h. Be courteous to customers and co-workers.
   i. Communicate effectively with people.
   j. Practice good personal hygiene.
   k. Participate in trade organizations.

4. b, d, e, f

5. The following answers may be listed in any order:

   a. Electrician's helper
   b. Installer
   c. Apprentice
   d. Journeyman
   e. Master electrician or contractor
   f. Maintenance electrician
   g. Electrical parts/equipment salesperson
   h. Inspector

6. The following answers may be listed in any order:

   a. Death
   b. Burns
   c. Broken bones or bruises
   d. Sprains or muscle tear

7.-8. Evaluated to the satisfaction of the instructor

GENERAL SAFETY
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify hazardous conditions on the job and practice good safety. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 100 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to general safety with their correct definitions.
2. Complete statements concerning personal safety rules.
3. Select true statements concerning general safety rules.
4. List three shop conditions that should be reported.
5. Select true statements concerning things OSHA expects of an employer.
6. Select from a list things OSHA expects of an employee.
7. Match colors of the safety color code with their correct uses.
8. Match safety tags or signs with their correct color coding.
9. List the three components of the fire triangle.
10. Match types of fires with their classifications.
11. Match types of fire extinguishers with their uses.
12. Match factors contributing to back injuries with their causes.

OBJECTIVE SHEET

13. Arrange in order the steps in lifting safely.
14. Select true statements concerning safety practices for step ladders and extension ladders.
15. Select true statements concerning safety practices for scaffolds.
16. Select true statements concerning safety practices for power lifts.
17. Select true statements concerning hazardous cleaners and lubricants.
18. Complete statements concerning storage of hazardous materials.
19. Distinguish between hazardous materials that may be found at the job site.
20. Complete statements concerning general guidelines for first aid emergencies.
21. Select true statements concerning first aid for eye injuries.
22. Complete a student safety pledge form. (Assignment Sheet #1)
23. Identify and correct safety violations. (Assignment Sheet #2)
24. Draw a layout of your school shop and apply safety color code. (Assignment Sheet #3)

GENERAL SAFETY
UNIT II

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

(NOTE: Make copies of Handout #1 to distribute to students prior to discussing Objective V.)

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

1. Have a Red Cross representative give class demonstration on first aid and CPR.
2. Have local fire marshall or fire extinguisher company representative demonstrate the proper use of fire extinguishers.
3. Discuss the fire evacuation plan for the classroom and shop, including evacuation routes and fire exits, as well as after-emergency evacuation routes and procedures for tornado alerts.
4. Have local OSHA inspector give talk.
5. Invite a safety representative from local industry to talk to class about safety practices and procedures.
6. Obtain safety slides or films and show to class.
7. Show students examples of safety tags and signs.
8. Discuss the Good Samaritan Act and your state's policy on using lifesafing techniques in emergency situations.
9. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *ABC's of Fire Protection*. Belleville, NJ: Walter Kidde & Co., Inc., 1978.

B. *Safety in Electrical Maintenance*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

C. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

SUGGESTED SUPPLEMENTAL MATERIAL

Publications

A. *American Red Cross: Adult CPR*. American National Red Cross, 1987.

(NOTE: Contact your local Red Cross chapter to order this publication.)

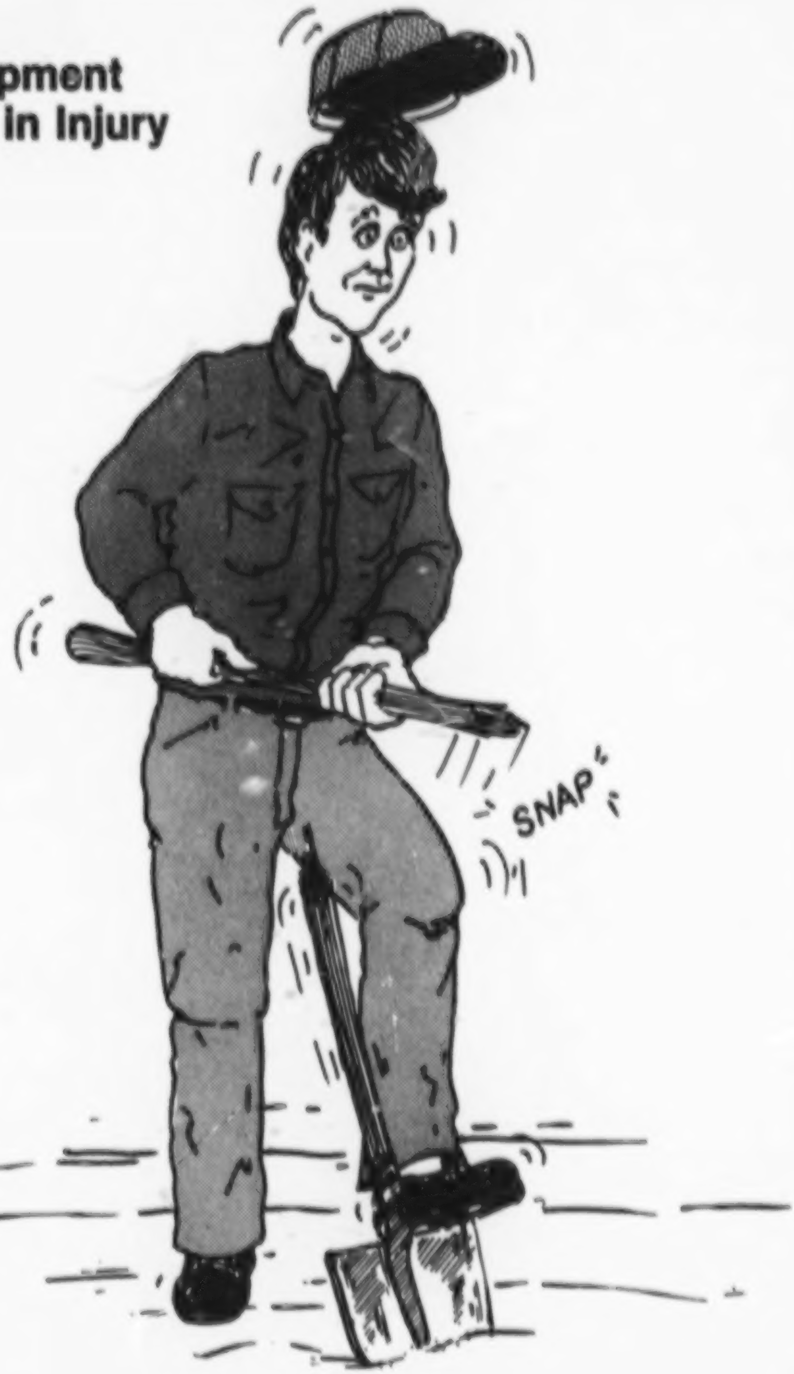
B. *The American Red Cross, Standard First Aid and Personal Safety*. Garden City, NY: Doubleday and Co., Inc., 1978.

C. *OSHA Safety and Health Standards*. Washington, D.C. 20402: U.S. Department of Labor, Occupational Safety, and Health Administration.

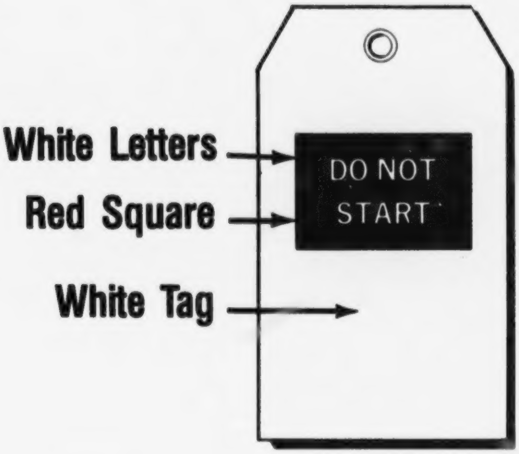
Film — *Safety in Electrical Maintenance*. Color film. NUS Training Corporation, 1350 Piccard Drive, Rockville, MD 20850.

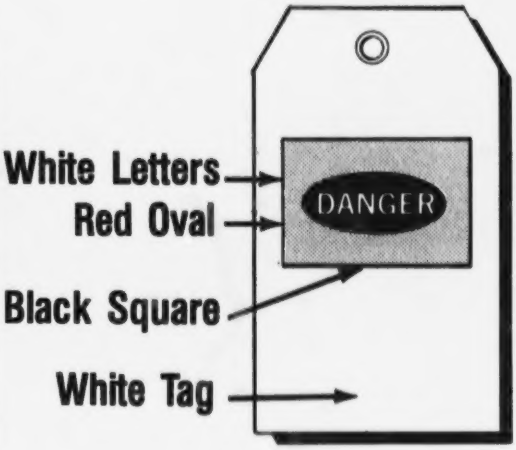
Maintain Tools

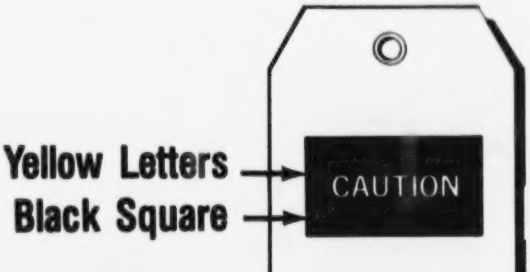
Faulty Equipment Can Result in Injury

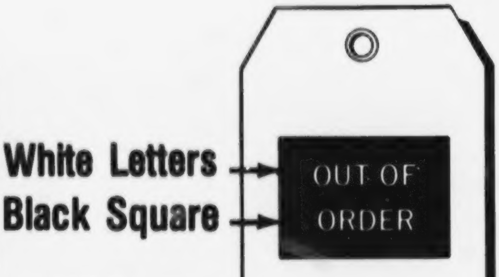


Safety Tag Color Codes

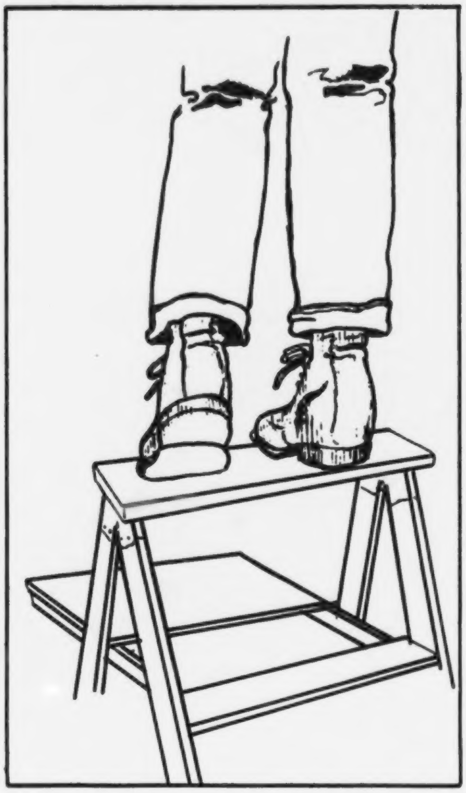

White Letters
Red Square
White Tag
DO NOT START


White Letters
Red Oval
Black Square
White Tag
DANGER

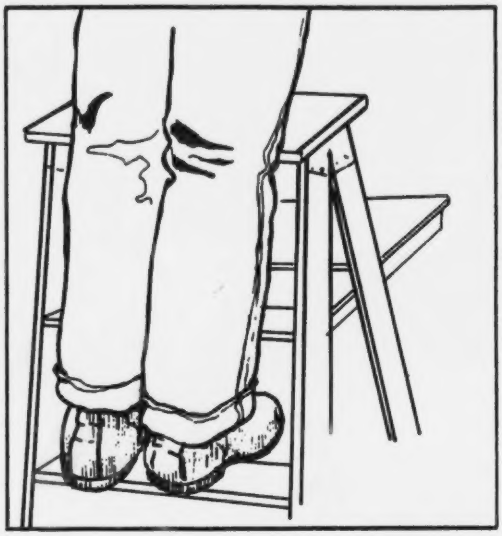

Yellow Letters
Black Square
Yellow Tag
CAUTION


White Letters
Black Square
White Tag
OUT OF ORDER

Safety Practices for Step Ladders

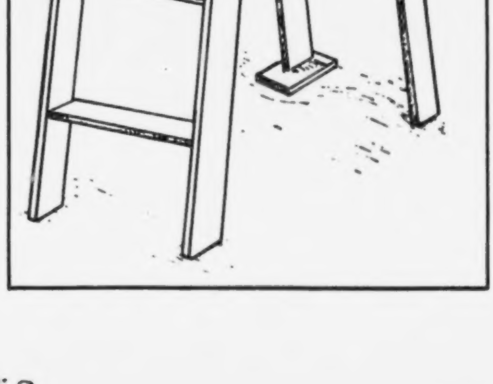


Incorrect

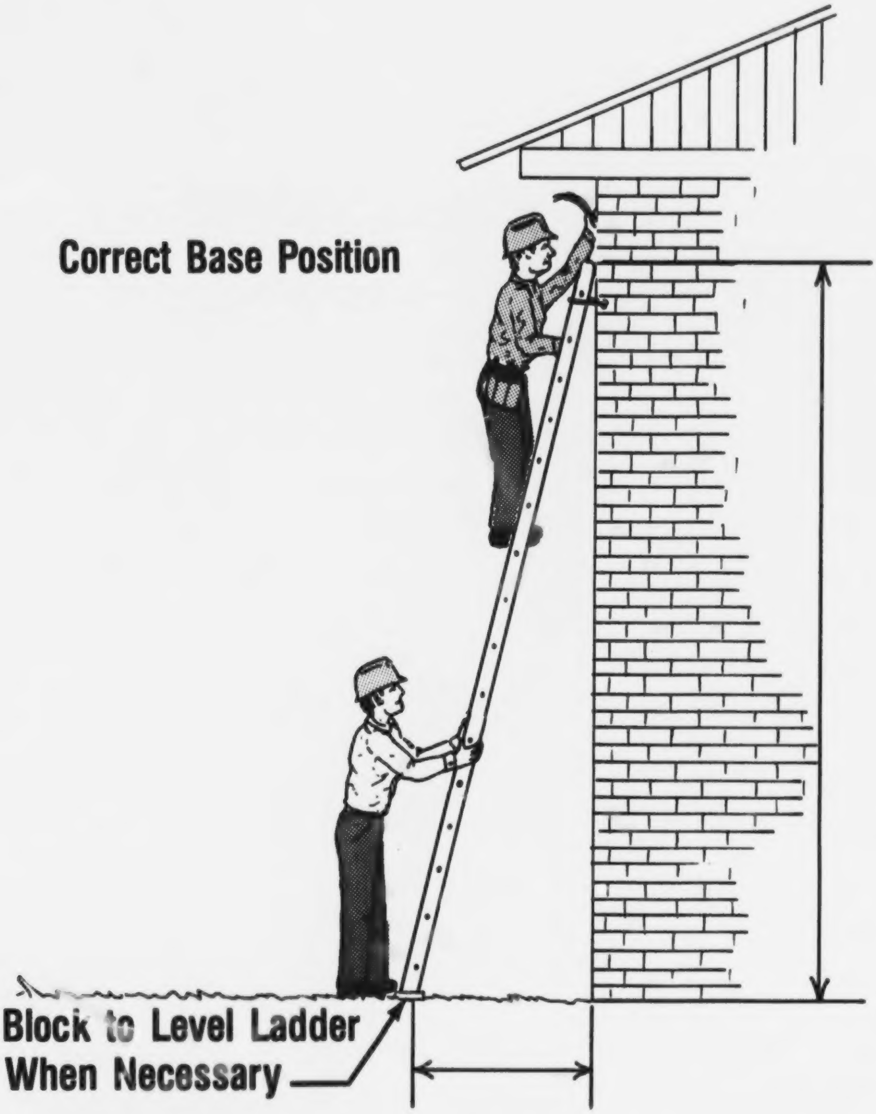


Correct

Use Block to Level Ladder
When Necessary

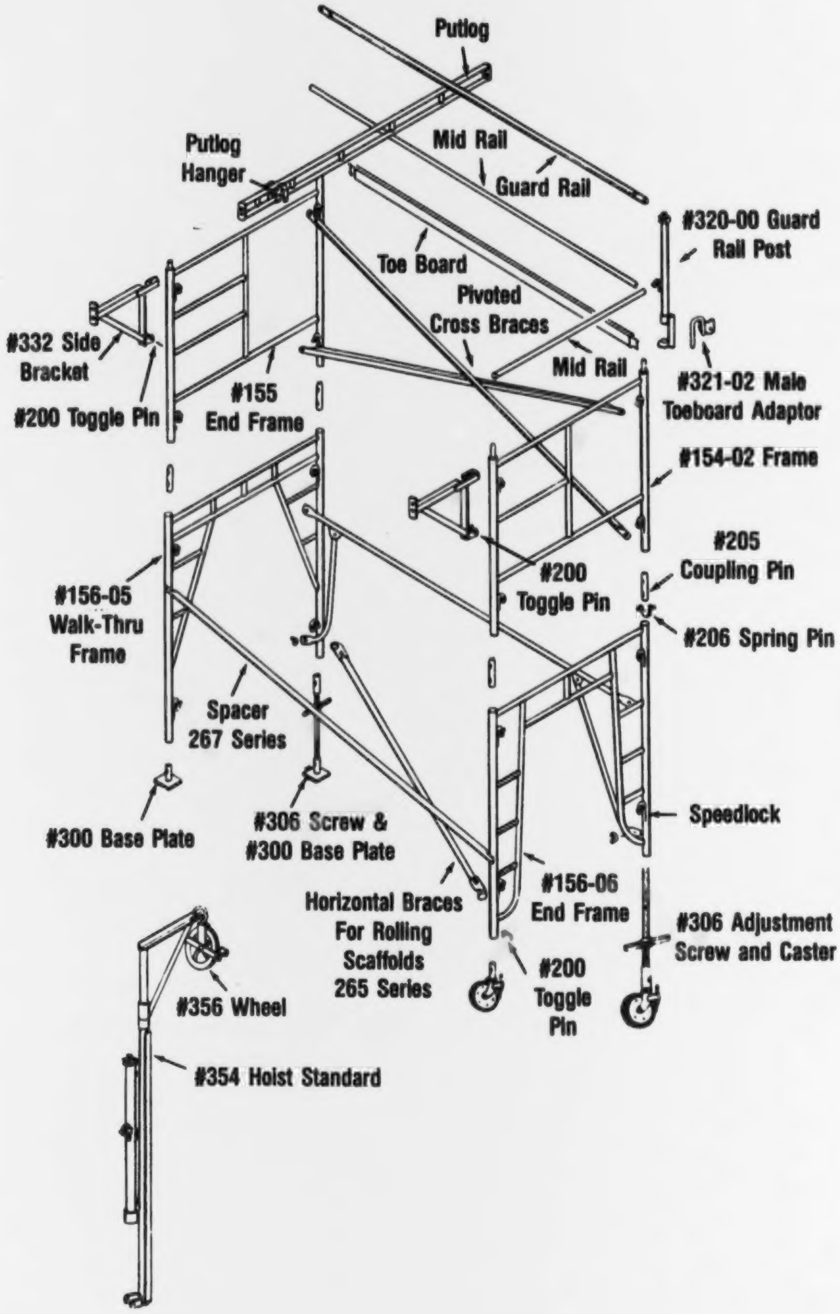


Safe Ladder Angle


Correct Base Position
Use Block to Level Ladder When Necessary

Correct Base Position is 1/4 the Vertical Height

Construction of Scaffold


Putlog
Putlog Hanger
Mid Rail
Guard Rail
#320-00 Guard Rail Post
Toe Board
Pivoted Cross Braces
#332 Side Bracket
#200 Toggle Pin
#155 End Frame
Mid Rail
#321-02 Male Toeboard Adaptor
#154-02 Frame
#205 Coupling Pin
#200 Toggle Pin
#156-05 Walk-Thru Frame
#206 Spring Pin
Spacer 267 Series
#300 Base Plate
#306 Screw & #300 Base Plate
Speedlock
Horizontal Braces For Rolling Scaffolds 265 Series
#156-06 End Frame
#306 Adjustment Screw and Caster
#200 Toggle Pin
#356 Wheel
#354 Hoist Standard

GENERAL SAFETY
UNIT II

HANDOUT #1 — OSHA POSTER #2203

job safety and health protection

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers through the promotion of safe and healthful working conditions throughout the Nation. Requirements of the Act include the following:

Employers: **Each employer shall furnish to each of his employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to his employees; and shall comply with occupational safety and health standards issued under the Act.**

Employees: **Each employee shall comply with all occupational safety and health standards, rules, regulations and order issued under the Act that apply to his own actions and conduct on the job.**

The Occupational Safety and Health Administration (OSHA) of the Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to ensure compliance with the Act.

Inspection: The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint: Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or otherwise exercising their rights under the Act.

An employee who believes he has been discriminated against may file a complaint with the nearest OSHA office within 30 days of the alleged discrimination.

Citation: If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty: The Act provides for mandatory penalties against employers of up to $1,000 for each serious violation and for optional penalties of up to $1,000 per day may be proposed for failure to correct violations within the proposed time period. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $10,000 for each such violation.

Criminal penalties are also provided for in the Act. Any willful violation resulting in death of an employee, upon conviction, is punishable by a fine of not more than $10,000 or by imprisonment for not more than six months, or by both. Conviction of an employer after a first conviction doubles these maximum penalties.

Voluntary Activity: While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce injuries and illnesses arising out of employment.

The Department of Labor encourages employers and employees to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries.

Such cooperative action would initially focus on the identification and elimination of hazards that could cause death, injury, or illness to employees and supervisors. There are many public and private organizations that can provide information and assistance in this effort, if requested.

More Information: **Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:**

Atlanta, Georgia
Boston, Massachusetts
Chicago, Illinois
Dallas, Texas
Denver, Colorado
Kansas City, Missouri
New York, New York
Philadelphia, Pennsylvania
San Francisco, California
Seattle, Washington

Telephone numbers for these offices, and additional Area Office locations, are listed in the telephone directory under the United States Department of Labor in the United States Government listing.

Washington, D.C
1981
OSHA 2203

Raymond J Donovan

Raymond J. Donovan
Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration
GPO [illegible]

GENERAL SAFETY
UNIT II

INFORMATION SHEET

I. **Terms and definitions**

A. Accident — Any suddenly occurring, unintentional event which causes injury or property damage

B. Combustibles — Materials or liquids that catch fire easily

C. Cardiopulmonary resuscitation (CPR) — Emergency procedure performed by trained individuals to aid a heart attack victim

D. Fire extinguisher — That which quickly puts out fires or at least smothers flames

E. First aid — Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

F. Hazard — A potential source of danger

G. Occupational Safety and Health Administration (OSHA) — Federal legislation designed to insure safe and sanitary working conditions for employees

H. Safety — State or condition of being safe; freedom from danger, risk, or injury

I. Shock — The sudden stimulation of the nerves and muscles caused by the discharge of electricity through the body; shock can occur if the body contacts an electrical circuit and can cause serious burns and muscle damage

(NOTE: Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.)

II. **Personal safety rules**

A. Wear shop clothing appropriate to the instructional activity being performed.

(NOTE: Hard hats and safety shoes should be worn on all construction sites.)

B. Confine long hair before operating rotating equipment.

C. Always wear safety glasses.

D. Remove ties when working around machine tools or rotating equipment.

INFORMATION SHEET

E. Remove rings and other jewelry when working in the shop.

F. Conduct yourself in a manner conducive to safe shop practices.

G. Use soap and water frequently as a method of preventing skin diseases.

H. Use suitable helmets and goggles for welding.

I. Wear dust masks in dusty areas.

J. Wear hearing protection when subjected to continuous loud noise.

III. General safety rules

A. Keep all hand tools sharp, clean, and in safe working order.

B. Retain all guards and safety devices except with the specific authorization of the instructor.

C. Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.

D. Turn off the power before leaving a machine tool.

E. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool.

F. Disconnect the power from machine tools before performing the maintenance task of oiling or cleaning.

(NOTE: Tag out or lock out machine when being maintained.)

G. Use a solvent only after determining its properties, what kind of work it has to do, and how to use it.

H. Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held.

I. Keep working areas clean and free of debris and other hazards.

J. Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.

K. Clean up any spilled liquids immediately.

L. Store oily rags or oily waste in self-closing or spring-lid metal containers.

M. Keep sufficient brooms, brushes, and other housekeeping equipment readily available.

INFORMATION SHEET

N. Clean the chips from a machine with a brush, not with a rag or bare hands.

O. Wear eye protection when using grinders and buffers.

P. Do not work overtime in the shop unless instructor is present.

Q. Consider the safety of others.

R. Do not throw objects while in the shop.

S. Wear gloves when handling equipment and materials with sharp edges.

T. Do not distract people operating machines.

U. Check all equipment before activating.

V. Be aware of surroundings before power tool is plugged in.

EXAMPLE: Are there any explosives or combustible materials in the area?

W. Work with adequate light.

X. Do not run over cords with dollies or carts.

IV. Shop conditions that should be reported

A. Defects on equipment

B. Any condition that can lead to an accident

C. All accidents

V. Things OSHA expects of an employer

A. To provide a hazard-free workplace and comply with occupational safety and health standards

B. To inspect job sites to assure they meet safety standards

C. To use properly color-coded signs to warn of danger

D. To keep required records of work-related injuries and to post an annual summary in February of each year

E. To report within 48 hours to OSHA any accident which is fatal or hospitalizes five or more workers

F. To post in a prominent place OSHA poster #2203 informing workers of their rights and responsibilities

INFORMATION SHEET

VI. **Things OSHA expects of an employee**

A. Read the OSHA poster #2203 and comply with its standards.

B. Follow employer safety and health rules and wear prescribed clothing or protective equipment on the job.

C. Report hazardous conditions to a supervisor.

D. Report all job-related injuries to a supervisor and seek prompt treatment if required.

E. Report to OSHA in a responsible manner any hazardous working situations which you feel the employer has not attended to properly.

VII. **Colors of the safety color code and their uses**

(NOTE: The following colors identify safe and unsafe conditions in the shop. Learn the color code because it could help you prevent accidents to yourself and fellow workers.)

A. Federal safety red — Basic color for identifying

1. Fire protection equipment and apparatus
2. Portable containers of flammable liquids
3. Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

B. Federal safety yellow — Basic color for designating

1. Caution and for marking physical hazards
2. Waste containers for explosive or combustible materials
3. Caution against starting, using, or moving equipment under repair
4. Identification of the starting point or power source of machinery

C. Federal safety orange — Basic color for designating

1. Dangerous parts of machines
2. Safety starter buttons and parts of equipment that may produce electrical shock
3. The exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

INFORMATION SHEET

D. Federal safety purple — Basic color for designating radiation hazards

E. Federal safety green — Basic color for designating

  1. Safety
  2. Location of first aid equipment

     (NOTE: This applies to equipment other than fire fighting equipment.)

F. Federal safety black and white — Basic colors for designating

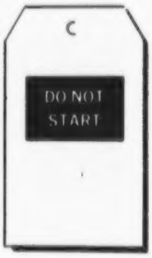
  1. Traffic flow
  2. Housekeeping zones

(NOTE: These are used individually or in combination.)

VIII. Color coding of safety tags or signs

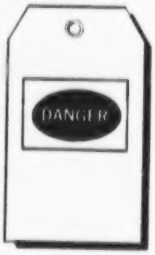
A. Do not start tag

  1. White tag
  2. White letters on red square



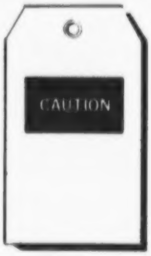
B. Danger tag

  1. White tag
  2. White letters in red oval, on black square



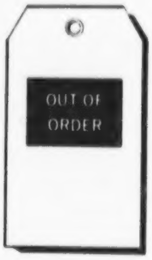
C. Caution tag

  1. Yellow tag
  2. Yellow letters on black background



D. Out of order tag

  1. White tag
  2. White letters on black background



INFORMATION SHEET

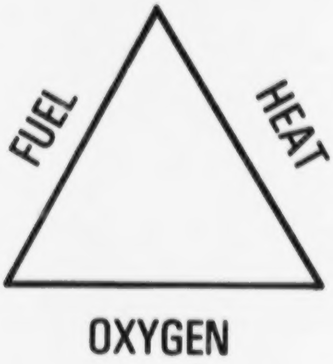
IX. **Components of the fire triangle**

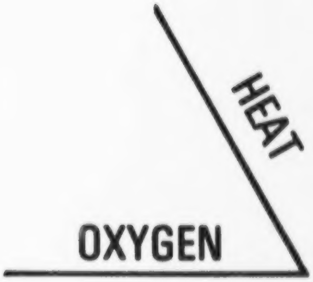
A. Fuel — Any combustible material

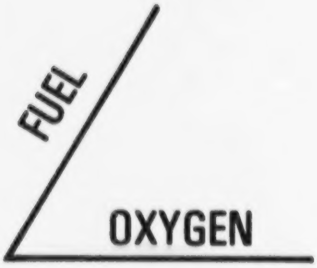
B. Heat — Enough to raise the fuel to its ignition temperature

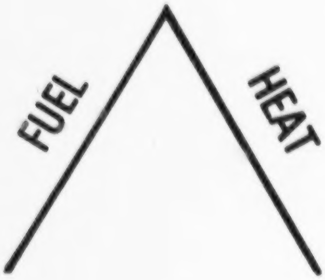
C. Oxygen — Necessary to sustain combustion

(NOTE: To produce fire, three things must be present at the same time. If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.)


FUEL
HEAT
OXYGEN


HEAT
OXYGEN


FUEL
OXYGEN



INFORMATION SHEET

X. **Types of fires and their classifications**

A. Class A — Fires that occur in ordinary combustible materials

EXAMPLES: Wood, rags, paper, or trash

B. Class B — Fires that occur in flammable liquids

EXAMPLES: Gasoline, oil, grease, paints, and thinners

C. Class C — Fires that occur in electrical and electronic equipment

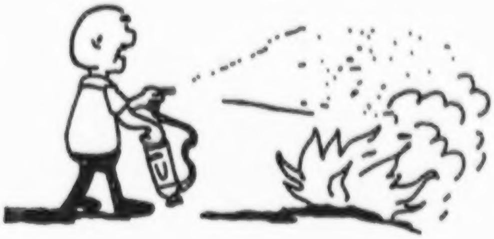
EXAMPLES: Motors, switchboards, circuit wiring, radios, and television sets

D. Class D — Fires that occur in combustible metals

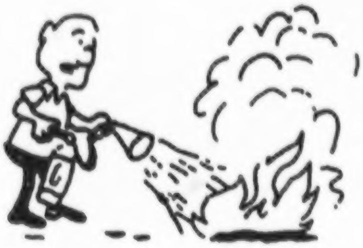
EXAMPLES: Powdered aluminum and magnesium

XI. **Types of fire extinguishers and their uses**

A. Foam — Instead of spraying stream into the burning liquid, allow foam to fall lightly on the fire; use for class A or class B fires.

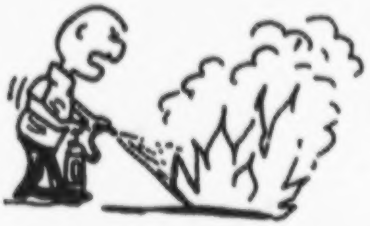


B. Carbon dioxide — Direct discharge as close to fire as possible, first at the edge of flames, then gradually forward and upward; use for class B or class C fires.

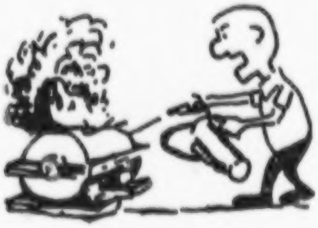


INFORMATION SHEET

C. Pump tank — Place foot on foot pump and direct stream at base of fire; use on **class A** fires only.



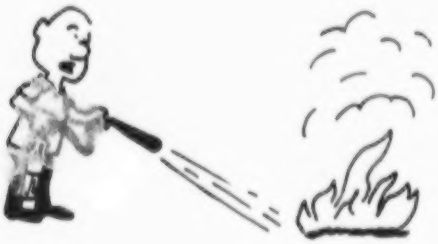
D. Dry chemical — Direct at the base of the flames; follow up by directing the dry chemicals at remaining materials that are burning; use for class B or class C fires.



E. Halon — Stand back ten feet, hold upright, and direct at the base of fire, sweeping from side to side; use for class C fires.

(NOTE: Halon is a clean, liquified gas which does not leave a residue.)

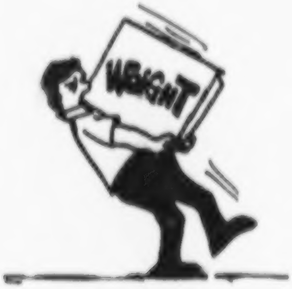
(CAUTION: A high concentration of burnt halon gas may be hazardous to your health.)



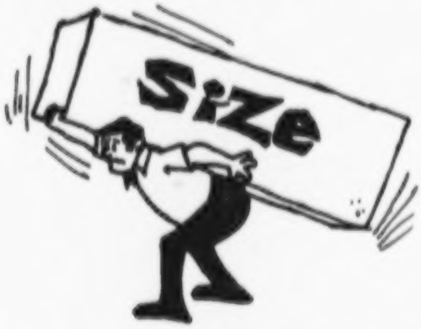
INFORMATION SHEET

XII. **Factors contributing to back injuries and their causes**

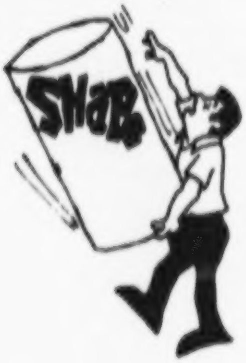
A. Weight — This usually results from overestimating your physical abilities and trying to lift more weight than you can handle, and sometimes it results from trying to be macho in front of fellow workers.



B. Size — This usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

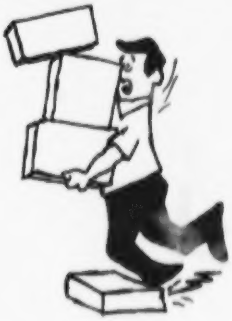


C. Shape — This usually results from moving an object that may be within your weight capacity, but has a cylindrical shape or other odd shape that makes safe lifting difficult.

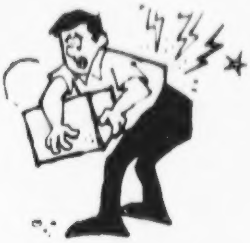


INFORMATION SHEET

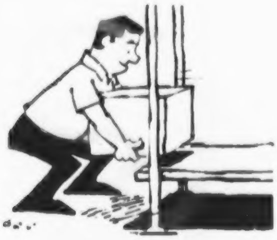
D. Obstructions — This usually results from stacking materials so high that vision is limited and obstructions in the pathway can't be seen.



E. Improper position — This usually results from twisting or turning into an awkward position when lifting.

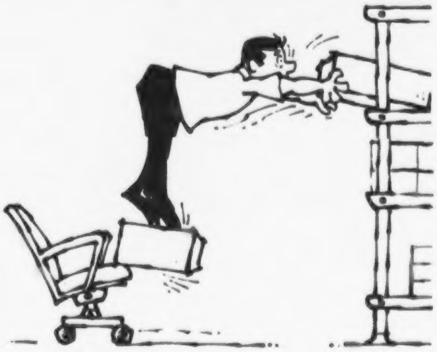


F. Improper storage — This results in strain caused by not storing heavy objects at least 12" off the floor.



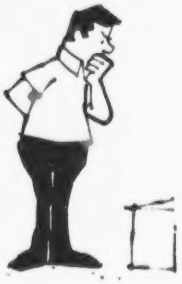
INFORMATION SHEET

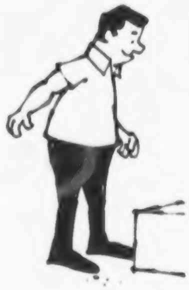
G. Improper reaching — This usually results from carelessly using chairs or boxes to reach from instead of safely using a ladder.



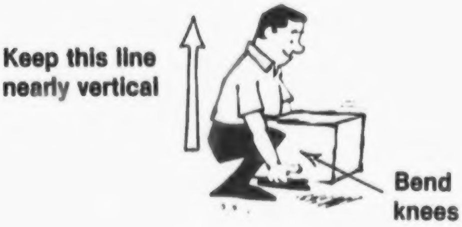
XIII. **Steps in lifting safely**

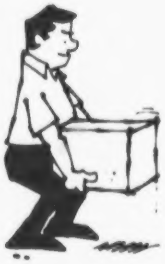
A. Size up the load to make sure you can safely handle it alone, and then place your feet close to the object and about 12" apart.





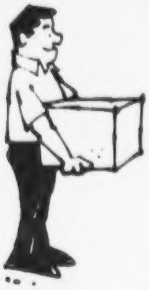
B. Bend your knees, get a good hand hold, then use both legs and back muscles to lift the load straight up as you push with your legs and keep the load close to your body.

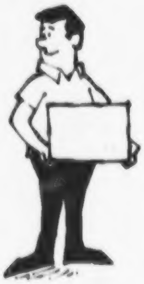

Keep this line nearly vertical
Bend knees



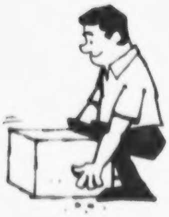
INFORMATION SHEET

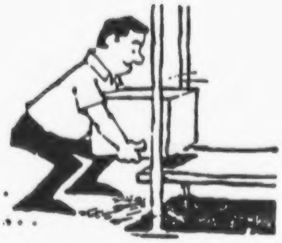
C. Do not turn or twist until you have the load lifted into a carrying position, then move your feet to turn your body as you check your path of travel to make sure it is clear.





D. Lower the load by bending your knees, and remember to store heavy objects at least 12" off the floor.

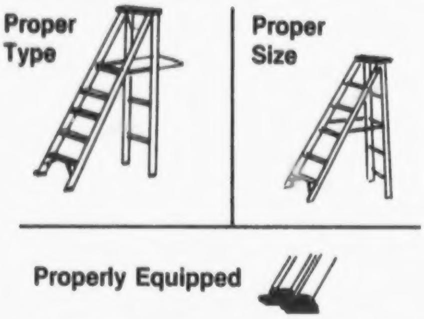




XIV. Safety practices for step ladders and extension ladders

A. Secure top of ladder when possible.

B. Make sure ladder is proper type, proper size, and properly equipped.



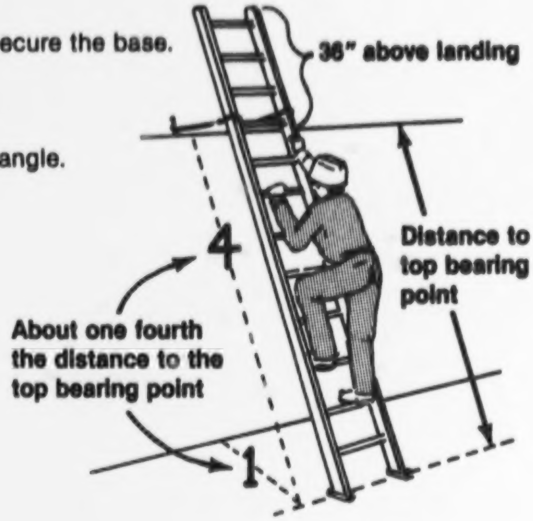
(NOTE: Top step should be platform height so that the worker can exit through rails rather than around ladder.)

INFORMATION SHEET

C. Use nonskid feet or secure the base.

D. Secure top of ladder.

E. Maintain safe ladder angle.


36" above landing
Distance to top bearing point
4
About one fourth the distance to the top bearing point
1

F. Never leave tools or equipment on footsteps or top.

G. Never stand on ladder tops.

H. Never use damaged ladders until repaired.

I. Set ladders on firm, level surface.

(NOTE: Block up legs if necessary to firm up a ladder.)

J. Never use aluminum ladders in electrical work.

K. Have attendant present if located in a walkway or roadway.

XV. **Safety practices for scaffolds**

A. Never climb a scaffold unless all four legs are on the ground.

B. Secure wheel locks before moving.

C. Get help when assembling the scaffold.

D. Never ride scaffold when it is being moved.

E. Always use proper planks when assembling.

(NOTE: See manufacturer's instructions before constructing scaffolds.)

INFORMATION SHEET

XVI. **Safety practices for power lifts**

A. Never lift over the weight-rated capacity of the lift.

B. Operate lift on smooth surfaces if possible.

C. Always check for objects in the pathway.

D. Never put arms or legs in lift.

E. Always use caution when moving lift.

XVII. **Hazardous cleaners and lubricants**

(NOTE: Many cleaners and lubricants contain petroleum, acids, and or alkaline bases which may be hazardous to your health. Read labels for proper use and storage.)

Cleaner	*Type*	*Application*
Alcohol, ethyl	Petroleum solvent	Cleaning solder connections Thinner for shellac and rosin
Acetone	Petroleum solvent	Removal of oily films, paints, and lacquer Lucite cement
Bright dip	Acid mixture containing sulfuric, hydrochloric, and nitric acids	Cleaning metal surfaces after etching or soldering
Butyl cellulose	Petroleum solvent	Thinner and wash-up for epoxy resin inks
Cyclohexanone	Petroleum solvent	Vinyl solvent and cement thinner
Hydrochloric acid	Diluted acid	Remove mill scale from steel Bright dip ingredient
Isophorone	Petroleum solvent	Wash-up for vinyl inks
Isopropyl alcohol	Petroleum solvent	For removing oil, grease, and flux from conductors and terminals both before and after soldering

INFORMATION SHEET

Cleaner	*Type*	*Application*
Kerosene	Petroleum solvent	Machine cutting fluid
Ketone, methyl ethyl	Petroleum solvent	Lacquer thinner and paint remover
Lacquer thinner	Petroleum solvent	Thinner and wash-up for lacquer and lacquer ink
Mineral spirits	Petroleum solvent	Wash-up and thinner for rubber, oil, ethyl cellulose inks, and alkyd enamels
Perchlorethylene	Chlorinated solvent	General-purpose cleaner and vapor degreaser
Phosphoric acid	Diluted acid	Remove milk scale from steel
Sodium hydroxide	Alkaline solvent	Cleaning and etching aluminum
Toluene	Petroleum solvent	Wash-up and thinner for rubber, oil, ethyl cellulose inks, and alkyd enamels
Trichloroethane	Chlorinated solvent	Wash-up layout dye and screen inks Ultrasonic cleaning
Trichlorethylene	Chlorinated solvent	General-purpose cleaner and vapor degreaser
Turpentine	Petroleum solvent	Machine cutting fluid
Xylene	Petroleum solvent	Thinner for acrylic printing inks Wash-up for synthetic enamels and photo resist ink

Lubricant	*Application*
WD40	General purpose lubricant
3-in-1 oil	General purpose lubricant

INFORMATION SHEET

XVIII. Storage of hazardous materials

A. Select an area that meets local, state, and national codes.

B. Store materials in metal cabinets.

C. Keep cabinet or storage area locked.

D. Store in an area away from open flame or excessive heat.

E. Always read labels for instructions on proper storage and use.

XIX. Hazardous materials that may be found at the job site

A. PCB's (Polychlorinated Biphenyls) — Are fire resistant and help to improve the coolant and dielectric properties of oil; they can be harmful if absorbed into the skin, and they are suspected of being cancer-causing agents

(NOTE: PCB's are considered serious environmental contaminants.)

B. Asbestos — Used on ceilings, boilers, and electrical wiring as a heat retardant; it is highly suspected of causing cancer

(NOTE: OSHA requires employers to test for asbestos fibers in the air. The results will determine what control measures will be taken to protect employees.)

XX. General guidelines for first aid emergencies

A. Before administering first aid, always have a reason for what you do.

B. Reassure the injured person that everything possible is being done.

(NOTE: Hearing the concerned voice of a co-worker is psychologically comforting to an injured person and can actually lessen the degree of shock.)

C. Make accurate notes about the accident including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

D. Do not notify the victim's family because this is the responsibility of the school, the job site supervisor, or the medical facility.

E. Report all accidents and injuries to your instructor or job site supervisor, no matter how minor they may seem.

(NOTE: Follow emergency procedures that have been adopted by local school board.)

INFORMATION SHEET

XXI. First aid for eye injuries

A. Every eye injury should receive immediate first aid attention.

B. Notify your supervisor or instructor immediately.

C. For an apparent minor object in the eye, have the person wink several times. If the tears produced by winking do not remove the object, assume that the object is embedded and use the following procedure:

   1. Have the victim close his or her eyes.
   2. Put a piece of moist cotton over the closed lid.
   3. Place a bandage over the cotton.
   4. Get the victim to a doctor as soon as possible.

D. When the eyeball has been obviously scratched or penetrated, apply a sterile dressing, bandage *loosely*, and get medical help immediately.

E. Never permit the victim of an eye injury to rub his or her eye.

F. When in doubt about any eye injury, seek the most immediate medical attention.

G. Even though damage may be confined to one eye, it is sometimes best to bandage both eyes with a sterile dressing so the victim will not have a tendency to move the damaged eye.

H. For chemical or acid splashes, flush the eyes immediately at an eye-flushing station or use a bottled, portable flushing solution, then seek immediate medical assistance.

GENERAL SAFETY
UNIT II

ASSIGNMENT SHEET #1 — COMPLETE A STUDENT SAFETY PLEDGE FORM

____________________________________, who is enrolled in Vocational _________________ ________________________________, will as a part of his/her shop experience, operate machines, providing that the parent or guardian gives written permission.

It is important that each student will be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it. The student must assume responsibility for following safe practices, and we therefore ask that the student subscribe to the following safety pledge.

1. I promise to follow all safety rules for the shop.
2. I promise never to use a machine without first having permission from the instructor.
3. I will not ask permission to use a particular machine unless I have been instructed in its use, and have made 100% on the safety test for that machine.
4. I will report any accident or injury to the teacher immediately.

Date _____________ Student's signature ________________________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he or she is enrolled.

Date _____________ Parent's signature ________________________________

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

GENERAL SAFETY
UNIT II

ASSIGNMENT SHEET #2 — IDENTIFY AND CORRECT SAFETY VIOLATIONS

NAME ______________________________ SCORE ______________

DIRECTIONS: The following conditions relate unsafe acts that may be found in the classroom. List the safety violations and the corrective measures which should have been taken to prevent them.

The morning class was loading materials and equipment for their school project house. John, one of the students, went to the tool room and got the ½" drill motor that had a red tag attached to the power cord. John noticed there was a stripped wire on the drill but he didn't think it was that bad. John pulled the red tag off the drill and threw it in the trash. Then John went to the tape cabinet to find some electrical tape. The bell rang so John placed the drill with the other tools and went to catch the bus. When the afternoon class arrived they finished loading the tools and materials in the bus and went to the project house. Jim was assigned to drill out the house. He picked up the drill that John had left with the other tools and started to drill. It was very hot that day so Jim removed his shoes. The plumbing students were also working in the house testing water lines and the floor was covered with water. While drilling in the bathroom, Jim pulled the drill cord through the water and received a severe electrical shock.

A. List the safety violations.

____

____

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ASSIGNMENT SHEET #2

B. List the corrective measures which should have been taken.

GENERAL SAFETY
UNIT II

ASSIGNMENT SHEET #3 — DRAW A LAYOUT OF YOUR SCHOOL SHOP AND APPLY SAFETY COLOR CODE

NAME ______________________________ SCORE ____________

DIRECTIONS: Draw a layout of your school shop including all machines, workbenches, tools, first aid kit, and fire prevention equipment. Use the federal safety color code to identify equipment, hazards, safety features, and exposed parts that could cause accidents.

GENERAL SAFETY
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1 — Evaluated to the satisfaction of the instructor

Assignment Sheet #2

A. 1. Red warning tag was removed from drill
   2. Did not report stripped wire on drill to instructor
   3. Put drill with other tools
   4. Was going to try to fix drill cord with electrical tape
   5. Afternoon student did not check condition of drill before use
   6. Shoes were removed on job site while work was being done
   7. Water on floor was ignored

B. 1. John should have left red warning tag on drill.
   2.-3. He should have reported the damaged tool to the instructor and it should have been removed from other tools until fixed.
   4. Repair of tools should be handled by instructor or under instructor's supervision.
   5. John should have checked the condition of the drill prior to plugging it in.
   6. Never remove shoes on job site, especially when working with electrical equipment.
   7. The water spill should have been cleaned up. If water was still running as a result of plumbing work, John should have reported condition to instructor and been assigned another job.

Assignment Sheet #3 — Evaluated to the satisfaction of the instructor

GENERAL SAFETY
UNIT II

TEST

NAME ______________________________ SCORE ____________

1. Match terms on the right with their correct definitions.

______a. A potential source of danger

______b. That which quickly puts out fires or at least smothers flames

______c. Any suddenly occurring, unintentional event which causes injury or property damage

______d. Emergency procedure performed by trained individuals to aid a heart attack victim

______e. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

______f. Materials or liquids that catch fire easily

______g. State or condition of being safe; freedom from danger, risk, or injury

______h. Federal legislation designed to insure safe and sanitary working conditions for employees

______i. The sudden stimulation of the nerves and muscles caused by the discharge of electricity through the body

1. Accident
2. Combustibles
3. CPR
4. Fire extinguisher
5. First aid
6. Hazard
7. OSHA
8. Safety
9. Shock

2. Complete the following statements concerning personal safety rules by inserting the word(s) that best complete each statement.

a. Wear shop ______________ appropriate to the instructional activity being performed.

b. ______________ long hair before operating rotating equipment.

c. Always wear safety ______________ .

TEST

d. Remove ________________ when working around machine tools or rotating equipment.

e. Remove ________________ and other jewelry when working in the shop.

f. Conduct yourself in a manner conducive to safe ________________ practices.

g. Use ________________ and ________________ frequently as a method of preventing skin diseases.

h. Wear ________________ in dusty areas.

3. Select true statements concerning general safety rules by placing an "X" in the blanks preceding the true statements.

_____a. Keep all hand tools sharp, clean, and in safe working order.

_____b. Operate a hazardous machine before receiving instruction on how to operate the machine safely in all working conditions.

_____c. Turn off the power before leaving a machine tool.

_____d. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool.

_____e. Use a solvent only after determining its properties, what kind of work it has to do, and how to use it.

_____f. Clean up any spilled liquids when you have time.

_____g. Store oily rags or oily waste in plastic containers.

_____h. Clean the chips from a machine with a rag or bare hands.

_____i. Wear eye protection when using grinders and buffers.

_____j. Do not work overtime in the shop unless instructor is present.

_____k. Wear gloves when handling equipment and materials with sharp edges.

_____l. Check all equipment after activating.

4. List three shop conditions that should be reported.

a. ____

b. ____

c. ____

TEST

5. Select true statements concerning things OSHA expects of an employer by placing an "X" in the blanks preceding the true statements.

_____a. To provide a hazard-free workplace and comply with occupational safety and health standards

_____b. To inspect job sites to assure there are no obvious safety violations

_____c. To use properly color-coded signs to warn of danger

_____d. To keep required records of work-related injuries and to post an annual summary in February of each year

_____e. To report within two weeks to OSHA any accident which is fatal or hospitalizes five or more workers

_____f. To post in a prominent place OSHA poster #2203 informing workers of their rights and responsibilities

6. Select from the following list things OSHA expects of an employee by placing an "X" in the blanks preceding the correct things.

_____a. Post in a prominent place OSHA poster #2203 informing workers of their rights and responsibilities.

_____b. Follow employer safety and health rules and wear prescribed clothing or protective equipment on the job.

_____c. Expect supervisor to notice hazardous conditions.

_____d. Report all job-related injuries to a supervisor, and seek prompt treatment if required.

_____e. Report to OSHA in a responsible manner any hazardous working situations which you feel the employer has not attended to properly.

TEST

7. Match the colors of the safety color code on the right with their correct uses.

_____a. Designates caution and for marking physical hazards, waste containers for explosive or combustible materials, caution against starting, using, or moving equipment under repair, identification of the starting point or power source of machinery

_____b. Identifies fire protection equipment and apparatus, portable containers of flammable liquids, emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

_____c. Designates safety and the location of first aid equipment

_____d. Designates dangerous parts of machines, safety starter buttons, parts of equipment that may produce electrical shock, and the exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

_____e. Designates traffic flow, housekeeping zones

_____f. Designates radiation hazards

1. Federal safety green
2. Federal safety white and black
3. Federal safety orange
4. Federal safety purple
5. Federal safety red
6. Federal safety yellow

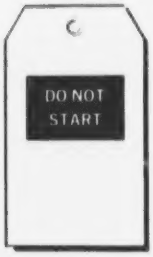
8. Match the following safety tags or signs below with their correct color coding.

_____a. White tag, white letters on red square

_____b. White tag, white letters in red oval, on black square

_____c. Yellow tag, yellow letters on black background

_____d. White tag, white letters on black background

1.


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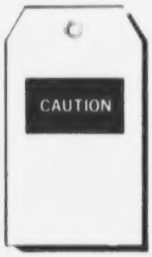

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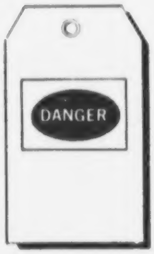

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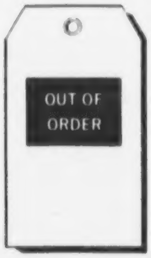


TEST

9. List the three components of the fire triangle.

a. ____

b. ____

c. ____

10. Match types of fires on the right with their correct classifications.

______a. Fires that occur in electrical and electronic equipment

______b. Fires that occur in flammable liquids

______c. Fires that occur in ordinary combustible materials

______d. Fires that occur in combustible metals

1. Class A
2. Class B
3. Class C
4. Class D

11. Match types of fire extinguishers on the right with their uses.

______a. Place foot on foot pump and direct stream at base of fire; use on **class A** fires only.

______b. Direct discharge as close to fire as possible, first at the edge of flames, then gradually forward and upward; use for class B or class C fires.

______c. Instead of spraying stream into the burning liquid, allow substance to fall lightly on the fire; use for class A or class B fires.

______d. Direct at the base of the flames and follow up by directing the dry chemicals at remaining material that is burning; use for class B or class C fires.

______e. Stand back ten feet, hold upright and direct at the base of fire, sweeping from side to side; use for class C fires.

1. Carbon dioxide
2. Halon
3. Pump tank
4. Dry chemical
5. Foam

TEST

12. Match factors contributing to back injuries on the right with their causes.

_____a. This usually results from overestimating your physical abilities and trying to lift more weight than you can handle, and sometimes it results from trying to be macho in front of fellow workers.

_____b. This usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

_____c. This usually results from moving an object that may be within your weight capacity, but has a cylindrical or other odd shape that makes lifting difficult.

_____d. This usually results from stacking materials so high that vision is limited and obstructions in the pathway can't be seen.

_____e. This usually results from twisting or turning into an awkward position when lifting.

_____f. This results in strain caused by not storing heavy objects at least 12" off the floor.

_____g. This usually results from carelessly using chairs or boxes to reach from instead of safely using a ladder.

1. Improper storage
2. Weight
3. Obstructions
4. Improper reaching
5. Size
6. Shape
7. Improper position

13. Arrange in order the steps in lifting safely. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Do not turn or twist until you have the load lifted into a carrying position, and then move your feet to turn your body as you check your path of travel and make sure it is clear.

_____b. Lower the load by bending your knees, and remember to store heavy objects at least 12" off the floor.

_____c. Bend your knees, get a good hand hold, then use both legs and back muscles to lift the load straight up as you push with your legs and keep the load close to your body.

_____d. Size up the load to make sure you can safely handle it alone, then place your feet close to the object and about 12" apart.

TEST

14. Select true statements concerning safety practices for step ladders and extension ladders by placing an "X" in the blanks preceding the true statements.

_____a. Never leave tools or equipment on footsteps or top.

_____b. Stand on ladder tops only when necessary.

_____c. Never use damaged ladders until repaired.

_____d. Be careful when using an aluminum ladder for electrical work.

_____e. Set ladder on a firm, level surface.

_____f. Step over broken or cracked footsteps.

_____g. Maintain safe ladder angle.

15. Select true statements concerning safety practices for scaffolds by placing an "X" in the blanks preceding the true statements.

_____a. Never ride a scaffold when it is being moved.

_____b. Scaffolding is easy to assemble and can be done alone.

_____c. Secure wheel locks before moving.

_____d. Always use the proper planks when assembling.

_____e. Never climb a scaffold unless three legs are on the ground.

16. Select true statements concerning safety practices for power lifts by placing an "X" in the blanks preceding the true statements.

_____a. Lifts should be operated on uneven surfaces.

_____b. Never lift over the weight-rated capacity of the lift.

_____c. Always check for objects in the pathway.

_____d. Never put arms or legs in lift.

_____e. When moving lift, assume workers will get out of the way.

TEST

17. Select true statements concerning hazardous cleaners and lubricants by placing an "X" in the blanks preceding the true statements.

_____a. Acetone is an acid which cleans solder connections.

_____b. Kerosene may be used as a machine cutting fluid.

_____c. Mineral spirits is a petroleum solvent which acts as a thinner for rubber, oil, and alkyd enamels.

_____d. Bright dip is an acid mixture containing sulfuric, hydrochloric, and nitric acids.

_____e. Lacquer thinner may be used as a coolant.

_____f. Isophorone is used for oil and grease wash-up.

_____g. Ethyl alcohol is not petroleum based.

_____h. Hydrochloric acid is diluted acid which removes mill scale from steel.

_____i. Cyclohexanone is a vinyl solvent and cement thinner.

18. Complete the following statements concerning storage of hazardous materials by circling the word(s) that best complete each statement.

a. Select an area that meets local, state, and national (**opinions, codes**).

b. Store materials in (**metal cabinets, plastic baskets**).

c. Keep storage area (**locked, open**).

d. Store in an open area (**near, away from**) open flame or excessive heat.

e. Always read (**text, labels**) for instructions on proper storage use.

19. Distinguish between hazardous materials that may be found at the job site by placing a "P" for PCB's next to the correct description.

_____a. Used on ceilings, boilers, and electrical wiring as a heat retardant; highly suspected of causing cancer

_____b. Fire resistant and help to improve the coolant and dielectric properties of oil; can be harmful if absorbed into the skin; suspected of being cancer-causing agents

TEST

20. Complete the following statements concerning general guidelines for first aid emergencies by inserting the word(s) that best completes each statement.

    a. Before administering first aid, always have a ________________ for what you do.

    b. ________________ the injured person that everything possible is being done.

    c. Make ________________ ________________ about the accident including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

    d. Do not ________________ the victim's family because this is the responsibility of the school, the job site supervisor, or the medical facility.

    e. Report all accidents and injuries to your instructor or job site supervisor, no matter how ________________ they may seem.

21. Select true statements concerning first aid for eye injuries by placing an "X" in the blanks preceding the true statements.

_____a. Every eye injury should receive immediate first aid attention.

_____b. Notify your supervisor or instructor after first aid has been administered.

_____c. For an apparent minor object in the eye, have the person wink several times. If the tears produced by winking do not remove the object, assume that the object is embedded and use the following procedure:

1) Have the victim close his or her eyes.

2) Put a piece of moist cotton over the closed lid.

3) Place a bandage over the cotton.

4) Get the victim to a doctor as soon as possible.

_____d. When the eyeball has been obviously scratched or penetrated, apply a sterile dressing, bandage *tightly*, and get medical help immediately.

_____e. Permit the victim of an eye injury to rub his or her eye.

_____f. When in doubt about any eye injury, seek the most immediate medical attention.

_____g. If damage is confined to one eye, it is best to bandage only that eye with a sterile dressing so the victim will be able to see.

_____h. For chemical or acid splashes, flush the eyes immediately at an eye-flushing station or use a bottled, portable flushing solution, then seek immediate medical assistance.

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

22. Complete a student safety pledge form. (Assignment Sheet #1)

23. Identify and correct safety violations. (Assignment Sheet #2)

24. Draw a layout of your school shop and apply safety color code. (Assignment Sheet #3)

GENERAL SAFETY
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 4
   c. 1
   d. 3
   e. 5
   f. 2
   g. 8
   h. 7
   i. 9

2. a. Clothing
   b. Confine
   c. Glasses
   d. Ties
   e. Rings
   f. Shop
   g. Soap, water
   h. Dust masks

3. a, c, d, e, i, j, k

4. a. Defects on equipment
   b. Any condition that can lead to an accident
   c. All accidents

5. a, c, d, f

6. b, d, e

7. a. 6
   b. 5
   c. 1
   d. 3
   e. 2
   f. 4

8. a. 1
   b. 3
   c. 2
   d. 4

ANSWERS TO TEST

9. a. Fuel
   b. Heat
   c. Oxygen

10. a. 3
    b. 2
    c. 1
    d. 4

11. a. 3
    b. 1
    c. 5
    d. 4
    e. 2

12. a. 2 e. 7
    b. 5 f. 1
    c. 6 g. 4
    d. 3

13. a. 3
    b. 4
    c. 2
    d. 1

14. a, c, e, g

15. a, c, d

16. b, c, d

17. b, c, d, h, i

18. a. Codes
    b. Metal cabinets
    c. Locked
    d. Away from
    e. Labels

ANSWERS TO TEST

19. b

20. a. Reason
    b. Reassure
    c. Accurate notes
    d. Notify
    e. Minor

21. a, c, f, h

22.-24. Evaluated to the satisfaction of the instructor

ELECTRICAL SAFETY
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to complete an electrical safety checklist and solve problems concerning electrical safety practices. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 100 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to electrical safety with their correct definitions.
2. List three major causes of electrical accidents.
3. Select from a list basic electrical safety practices.
4. Complete statements concerning electrical fire prevention practices.
5. Select true statements concerning safety practices around live circuits.
6. Select true statements concerning proper grounding.
7. List three facts about the importance of the third wire.
8. Explain ground fault interrupters.
9. List uses for lockout devices.
10. Complete statements concerning facts about electrical shock.
11. Select true statements concerning treating a victim of electrical shock.
12. Complete an electrical safety checklist. (Assignment Sheet #1)
13. Solve problems concerning electrical safety practices. (Assignment Sheet #2)

ELECTRICAL SAFETY
UNIT III

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

1. Demonstrate the proper use of lockout devices.
2. Set up scaffolding in the shop.
3. Demonstrate the function of a ground fault interrupter.
4. Have students survey the shop area for uses of ground fault interrupters.
5. Show students how to work safely with live voltages.
6. Have first aid personnel from local Red Cross or power supply company demonstrate rescue procedures for victims of electrical shock.
7. Have students make shop safety posters related to electrical safety.
8. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. Hartman, Lonnie. *Basic Electronics*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

B. *Safety in Electrical Maintenance*. Rockville, MD: NUS Training Corporation, A Halliburton Company, 1980.

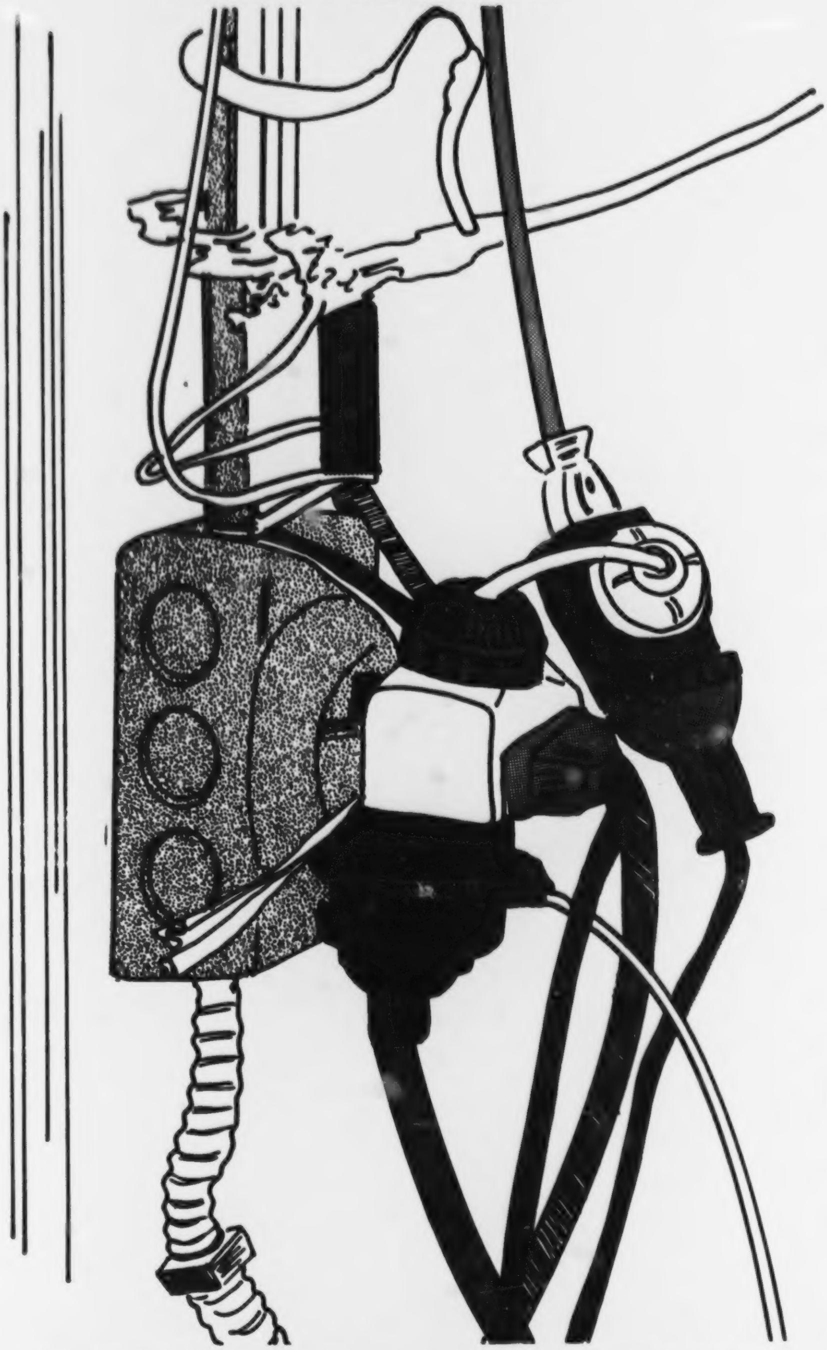
C. Taylor, Mark. *Residential Wiring*. Stillwater, OK Mid-America Vocational Curriculum Consortium, 1983.

D. Turner, J. Howard. *Understanding Electricity and Electrical Terms*. Athens, GA: American Association for Vocational Instructional Materials, 1974.

SUGGESTED SUPPLEMENTAL MATERIAL

Film — *Safety in Electrical Maintenance*. Color film. NUS Training Corporation, 1350 Piccard Drive, Rockville, MD 20850. PH: (301) 948-4200.

Fire Prevention

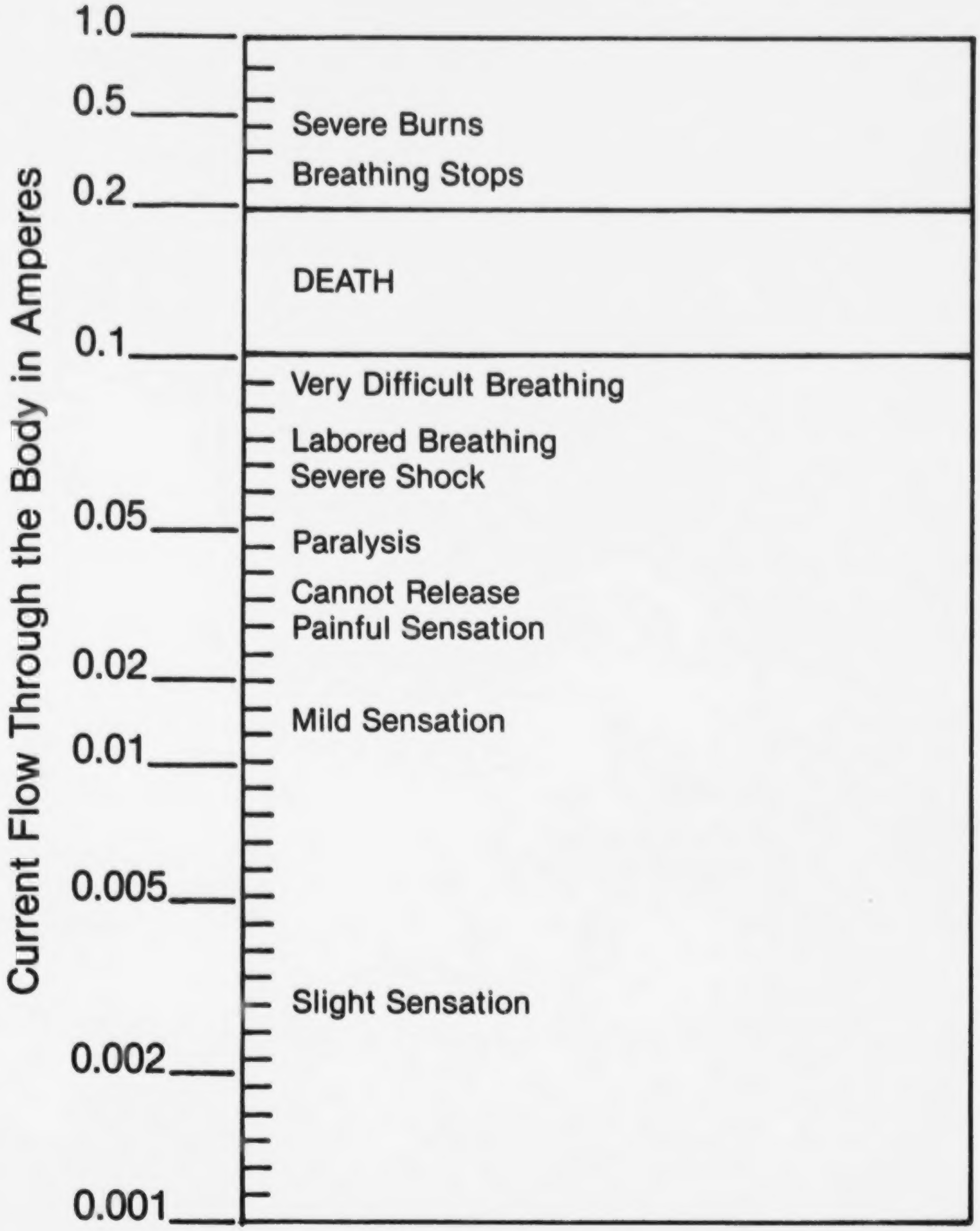


IMPROPER USE OF ELECTRICAL EQUIPMENT
IS DANGEROUS

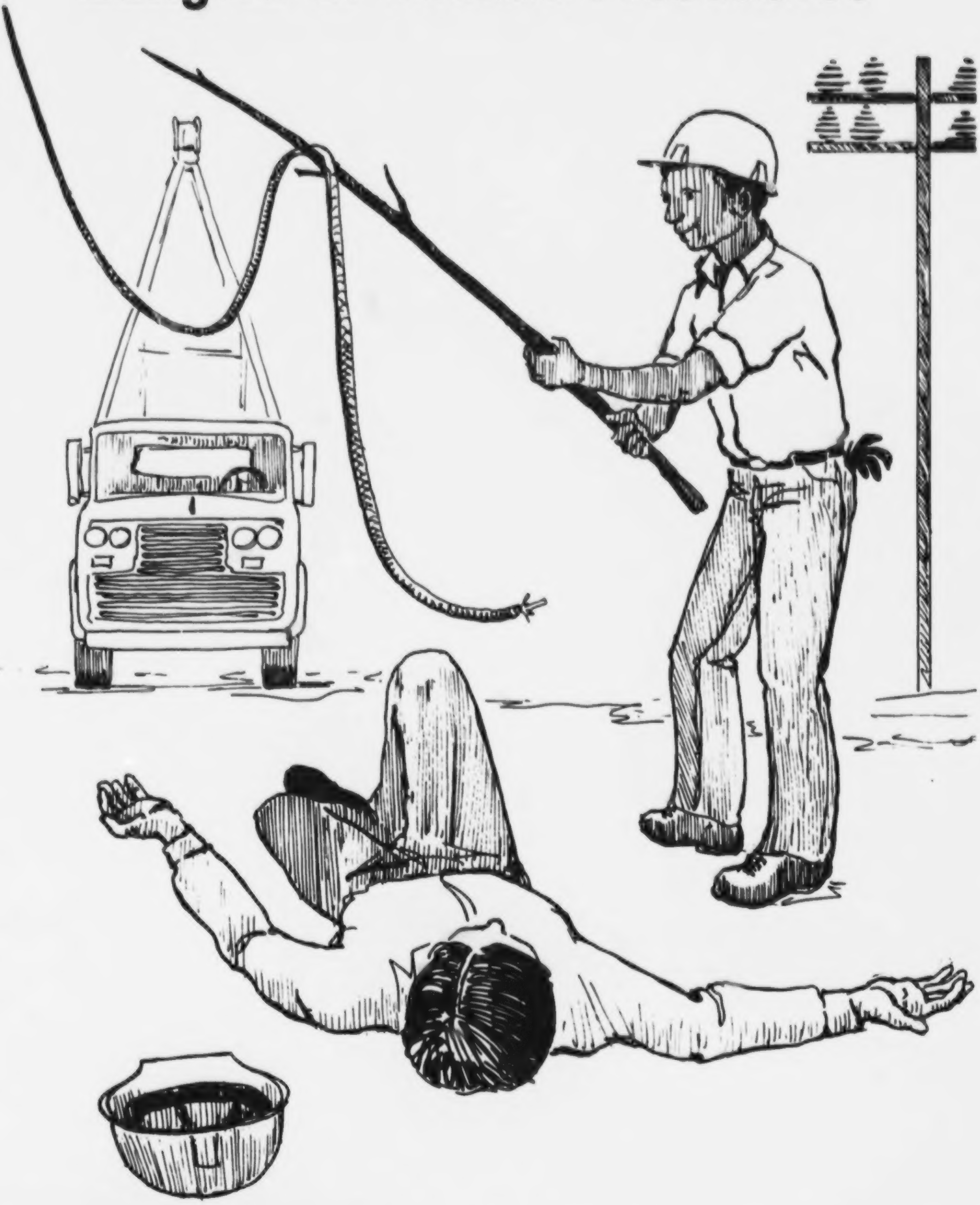
TM 1

Objective IV

Electric Shock Versus Body Sensation

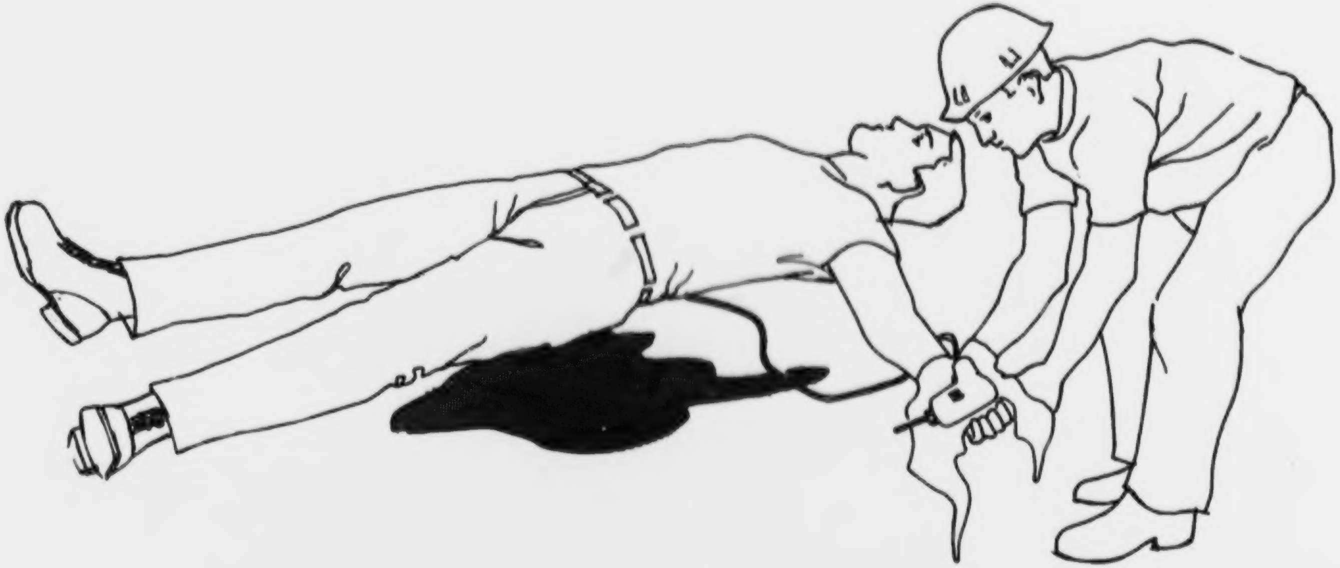


Dangers of Rescue Procedures



USE A NONCONDUCTOR TO SEPARATE VICTIM FROM ELECTRICAL CIRCUIT.
DO NOT TOUCH THE ELECTRICAL CIRCUIT OR THE VICTIM UNLESS THE POWER IS OFF OR YOU ARE INSULATED.

Dangers of Rescue Procedures
(Continued)



DO NOT ATTEMPT TO REMOVE A VICTIM WITHOUT SOME FORM OF INSULATION SUCH AS PAPER OR CLOTH TO PROTECT YOURSELF

ELECTRICAL SAFETY
UNIT III

INFORMATION SHEET

I. **Terms and definitions**

   A. Ampere — A measure of the intensity of electron flow

   B. Conductor — A current carrying device such as wire or copper bars

   C. Cube tap — A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

   D. Ground — A connection between an electrical circuit or equipment to the earth

   E. Ground fault interrupter — Personal protection device that stops current flow when an imbalance occurs between current carrying conductors

   F. Hertz — One complete positive to negative cycle in an alternating current circuit

   G. Hydraulic — A system where the main operation of equipment is operated by fluids

   H. Multi-outlet assembly — A type of surface or flush raceway designed to hold conductors and receptacles

   I. Pneumatics — A system where the main operation of equipment is operated by air

   J. Volt — Unit measure for electrical pressure

II. **Major causes of electrical accidents**

   A. Carelessness

   B. Misuse

   C. Getting in a hurry

III. **Basic electrical safety practices**

   A. Never underestimate the danger of 110v AC circuits.

      (NOTE: More people die from 110v AC electrical shock than any other voltage. This is mostly due to a lack of respect.)

   B. Watch out for electrical arcs; they can cause bad burns.

   C. Do not operate equipment beyond its rated capacity.

   D. Never install equipment that will overload a circuit.

INFORMATION SHEET

E. Never bypass a fuse.

F. Be sure all current carrying electric lines are well insulated.

G. Always check a circuit for voltage before servicing.

H. Know where all emergency shutdown switches are located.

I. Work on live circuits only when absolutely necessary.

J. Watch for burnt wires on electrical devices.

K. Never touch a conductor without first testing.

L. Look for loose conductors in electrical systems.

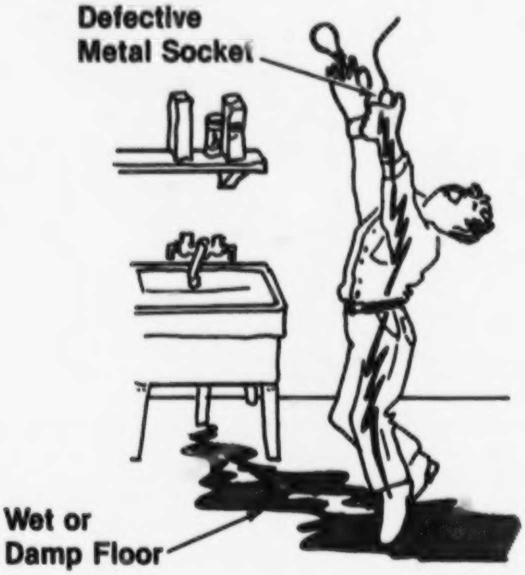
M. Do not make any adjustment or repairs to any electrical equipment until all power has been disconnected or the electrical breaker has been turned off.

(NOTE: Adjustments or repairs should be done only by authorized persons.)

N. All electrical equipment and tools should be properly grounded to prevent any injury to the operator.

O. Do not operate electrical parts with wet gloves or wet clothing.

(NOTE: To prevent harmful body shocks, keep hands, feet, and clothing dry, and use a dry board or rubber mat when water, moisture, or perspiration cannot be avoided.)



P. Never work alone when working with more than 50 volts.

INFORMATION SHEET

IV. Electrical fire prevention practices

A. Use extension cords only within their designated rating.

B. Never let multi-outlet assemblies or cube taps cause overloads.

C. Never use frayed or deteriorated extension cords.

D. Never tamper with fuses to change their current carrying capacity.

V. Safety practices around live circuits

A. Use a reliable circuit tester or voltmeter to identify live circuits.

B. Stand on dry surface.

C. Use only one hand if possible.

D. Never keep tools lying around live conductors.

E. Wear suitable insulated hand covering.

F. Return all tools to pouch when through with them.

VI. Proper grounding

A. Properly grounded electrical equipment provides a pathway to ground for stray current that may otherwise go through the operator's body.

B. Loose wires that touch the case or housing in electrical equipment can cause an electrical shock to anyone who touches the equipment if it has not been properly grounded.

(NOTE: A faulty current to the housing will travel directly to ground. A worker touching the equipment is not likely to suffer a serious shock because the ground is a better current path than the human body.)

C. Loose connections can be detected by heat on conductors, a burning odor, carbon tracking, and conductors that are discolored.

D. Always check electrical equipment for proper grounding before working on them.

E. Proper grounding allows ground fault current to clear overcurrent device providing safety of operation.

INFORMATION SHEET

VII. **Importance of third wire**

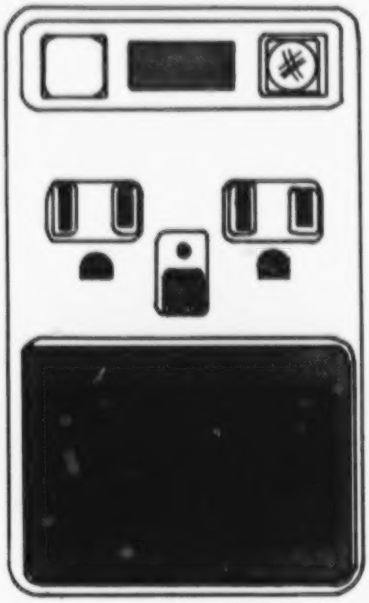
(NOTE: Always check for grounding or third wire before using electrical equipment to avoid electrical shock.)

A. Installed for personal protection

B. Provides alternate path for current in case of a short

C. Can save your life

VIII. **Ground fault interrupters (GFI)**



A. Personal safety devices

B. Required on 15 and 20 ampere receptacle outlets used for temporary power supply on construction sites

C. Stops current before severe personal injury occurs

(NOTE: When the ground fault interrupter works properly, the power is cut off so fast that the shock can be reduced to a few microseconds.)

INFORMATION SHEET

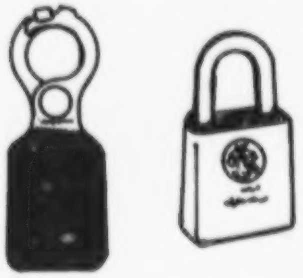
IX. **Uses for lockout devices**

A. Use if more than one power source is present.

B. Always use when hydraulic position could change.

C. Always use when pneumatic position could change.

D. Lock off all electrical devices before working on equipment.



X. **Facts about electrical shock**

A. High voltage (low current) tends to knock the victim away from the circuit, minimizing exposure time.

B. High current tends to cause the body to adhere to the circuit, so that the victim cannot let go.

1. At about 1 milliampere (0.0010 amperes), a slight shock will be felt.
2. At about 10 milliamperes (0.010 amperes) the shock is severe enough to paralyze muscles, but a person may be able to let go of the conductor.
3. At about 100 milliamperes (0.1 amperes) the shock is usually fatal if it lasts for one second or more.

(NOTE: Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.)

INFORMATION SHEET

XI. **Treating a victim of electrical shock**

A. Safely remove the victim from contact with the source of electricity using the following procedure.

(CAUTION: Do not touch the electrical circuit or the victim unless the power is off or you are insulated.)

1. Turn off the electricity by means of a switch or circuit breaker or cut cables or wires by means of a wood-handled axe or insulated cutters if available.

   (NOTE: This must be done quickly. After five minutes the chances of saving an individual will greatly decrease.)

2. Use a dry stick, rope, leather belt, coat, blanket, or any other nonconductor of electricity to separate the victim from the electrical circuit.

   (CAUTION: Do not take hold of the victim with your bare hand.)

B. Call for assistance

1. Others in the area may be more knowledgeable than you about treating the victim.

2. Another person can call for professional medical help while you administer first aid.

C. Check victim's breathing and heartbeat.

(NOTE: **TIME IS LIFE AT THIS POINT!**)

1. If pulse is detectable, but breathing has stopped, administer mouth-to-mouth resuscitation until medical help arrives.

2. If heartbeat has stopped, administer cardiopulmonary resuscitation, but only if you have been trained in the proper technique.

   (CAUTION: Cardiopulmonary resuscitation can sometimes cause more harm than good to a victim unless the person administering the first aid has been trained in the proper procedure.)

3. If both heartbeat and breathing have stopped, alternate between cardiopulmonary resuscitation and mouth-to-mouth resuscitation, but again only if you have been trained in this technique.

INFORMATION SHEET

D. Adminster first aid for shock and burns as necessary.

1. Use blankets or coats to help keep the victim as warm and comfortable as possible while waiting for help.

2. Raise victim's legs slightly above head level to help prevent shock.

3. If the victim has suffered burns:

    a. Cover your mouth and nostrils with gauze or a clean handkerchief to prevent breathing germs on the victim while treating the burns.

    b. Wrap burned area firmly with sterile gauze or clean linen or towels.

    (CAUTION: Do not attempt any other treatment of burns.)

E. Always continue treatment but only within your ability until medical help arrives.

ELECTRICAL SAFETY
UNIT III

ASSIGNMENT SHEET #1 — COMPLETE AN ELECTRICAL SAFETY CHECKLIST

NAME ______________________________ SCORE ______________

Directions: Complete the following electrical safety checklist for your school shop area, and list safety violations that you find.

Place a (✓) in the appropriate box

	YES	NO
1. Cords on all machines are properly connected.	☐	☐
2. Extension cords are used within designated rating.	☐	☐
3. Extension cords are in good working condition.	☐	☐
4. Shop area is properly wired.	☐	☐
5. All electrical hand tools are properly grounded.	☐	☐
6. All electrical equipment is properly grounded.	☐	☐
7. Ground fault interrupters are present and in working order.	☐	☐
8. All machines are marked with safety operations.	☐	☐
9. Shop safety rules are posted.	☐	☐
10. Safety lanes are marked using proper color designations.	☐	☐
11. Exits from shop area are properly marked.	☐	☐
12. Fire extinguishers are properly charged.	☐	☐
13. Fire extinguishers are easily accessible.	☐	☐
14. Areas around electrical equipment are clean and dry.	☐	☐
15. Areas around water fountains are clean and dry.	☐	☐
16. First aid kit is properly stocked and marked for identification.	☐	☐
17. Emergency numbers are posted at phone.	☐	☐
18. General housekeeping practices are observed.	☐	☐

ASSIGNMENT SHEET #1

Safety Violations

ELECTRICAL SAFETY
UNIT III

ASSIGNMENT SHEET #2 — SOLVE PROBLEMS CONCERNING ELECTRICAL SAFETY PRACTICES

NAME ______________________________ SCORE ______________

Directions: Solve the following problems concerning electrical safety practices. Refer to the Information Sheet in this unit to check your answers.

A. You are working on a project in the school shop and the person next to you shorts out his project and it catches fire. What are the safety procdures you should take?

____

____

____

____

B. While working at the project house, you hear a shout and turn to see a fellow worker has fallen to the floor with an electric line under his body. What is the very first thing you should do?

____

____

____

____

C. You are called out on a job after a storm to repair an electric pump in a basement which is flooded with water. List the things you should do before repairing the pump.

____

____

____

____

ELECTRICAL SAFETY
UNIT III

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

_____a. Personal protection device that stops current flow when an imbalance occurs between current carrying conductors

_____b. A system where the main operation of equipment is operated by air

_____c. A measure of the intensity of electron flow

_____d. Unit measure for electrical pressure

_____e. One complete positive to negative cycle in an alternating current circuit

_____f. A type of surface or flush raceway designed to hold conductors and receptacles

_____g. A device that plugs into a receptacle and provides space for connection of two or more attachment caps

_____h. A current carrying device such as wire or copper bars

_____i. A connection between an electrical circuit or equipment to the earth

_____j. A system where the main operation of equipment is operated by fluids

1. Ampere
2. Conductor
3. Cube tap
4. Ground
5. Ground fault interrupter
6. Hertz
7. Hydraulic
8. Multi-outlet assembly
9. Pneumatics
10. Volt

2. List three major causes of electrical accidents.

a. ____

b. ____

c. ____

TEST

3. Select from the following list basic electrical safety practices by placing an "X" in the blanks preceding the correct practices.

_____a. Since 110 volts is relatively low some safety rules can be ignored.

_____b. Watch out for electrical arcs; they can cause bad burns.

_____c. Know where all emergency shutdown switches are located.

_____d. Slight overloads are acceptable on most circuits.

_____e. Never bypass a fuse.

_____f. Always check a circuit for voltage before servicing.

_____g. Watch for burnt wires on electrical devices.

_____h. Operate equipment beyond its rated capacity.

_____i. Work alone when working with high voltage.

4. Complete the following statements concerning electrical fire prevention practices by inserting the word that best completes each statement.

a. Use extension cords only within their ________________ .

b. Never let multi-outlet assemblies or cube taps cause ________________ .

c. Never use ________________ or ________________ extension cords.

d. Never tamper with ________________ to change their current carrying capacity.

5. Select true statements concerning safety practices around live circuits by placing an "X" in the blanks preceding the true statements.

_____a. Use a reliable circuit tester or voltmeter to identify live circuits.

_____b. Stand on either wet or dry surface.

_____c. Use only one hand if possible.

_____d. Never keep tools lying around live conductors.

_____e. Wear suitable insulated hand covering.

TEST

6. Select true statements concerning proper grounding by placing an "X" in the blanks preceding the true statements.

_____a. Properly grounded electrical equipment provides a pathway to ground for stray current that may otherwise go through the operator's body.

_____b. Loose wires that touch the case or housing in electrical equipment cannot cause an electrical shock to anyone who touches the equipment if it has not been properly grounded.

_____c. Loose connections can be detected by heat on conductors, a burning odor, carbon tracking, and conductors that are discolored.

_____d. Always check electrical equipment for proper grounding before working on them.

7. List three facts about the importance of the third wire.

a. ______________________________

b. ______________________________

c. ______________________________

8. Explain ground fault interrupters.

____

____

____

____

9. List three uses for lockout devices.

a. ______________________________

b. ______________________________

c. ______________________________

TEST

10. Complete the following list of statements concerning facts about electrical shock by circling the word that best completes each statement.

    a. High **(current, voltage)** tends to knock the victim away from the circuit minimizing exposure time.

    b. High **(current, voltage)** tends to cause the body to adhere to the circuit so that the victim cannot let go.

    c. At about **(1,000, 100)** milliamperes the shock is severe enough to paralyze muscles, but a person may be able to let go of the conductor.

11. Select true statements concerning treating a victim of electrical shock by placing an "X" in the blanks preceding the true statements.

    _____a. To safely remove the victim from contact with the source of electricity, turn off the electricity by means of a switch or circuit breaker or cut cables or wires by means of a wood handled axe or insulated cutters.

    _____b. Call for assistance as others in the area may be more knowledgeable than you about treating the victim.

    _____c. Check victim's temperature.

    _____d. Check victim's breathing and heartbeat; if heart has stopped, administer cardiopulmonary resuscitation whether you have been trained in the proper technique or not.

    _____e. Use blankets or coats to help keep victim as warm and comfortable as possible while waiting for help.

    _____f. Raise victim's head slightly above body level to help prevent shock.

    _____g. If victim has suffered burns, wrap burned area firmly with sterile gauze or clean linen or towels.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Complete an electrical safety checklist. (Assignment Sheet #1)

13. Solve problems concerning electrical safety practices. (Assignment Sheet #2)

ELECTRICAL SAFETY
UNIT III

ANSWERS TO TEST

1. a. 5
   b. 9
   c. 1
   d. 10
   e. 6
   f. 8
   g. 3
   h. 2
   i. 4
   j. 7

2. a. Carelessness
   b. Misuse
   c. Getting in a hurry

3. b, c, e, f, g

4. a. Designated rating
   b. Overloads
   c. Frayed, deteriorated
   d. Fuses

5. a, c, d, e

6. a, c, d

7. a. Installed for personal protection
   b. Provides alternate path for current in case of a short
   c. Can save your life

8. Answer should include the following:

   Ground fault interrupters are personal safety devices which stop current before severe personal injury occurs. These devices are required on 15 and 20 ampere receptacle outlets which are used for temporary power supply on construction sites.

9. Any three of the following:

   a. Use if more than one power source is present.
   b. Always use when hydraulic position could change.
   c. Always use when pneumatic position could change.
   d. Lock off all electrical devices before working on equipment.

ANSWERS TO TEST

10.
  - a. Voltage
  - b. Current
  - c. 100

11. a, b, e, g

12.-13. Evaluated to the satisfaction of the instructor

HAND TOOLS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify, use, and care for common hand tools used in the electrical field. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to hand tools with their correct definitions.
2. Label common hand tools used in the electrical field.
3. Label electricity-specific hand tools used in the electrical field.
4. Match common hand tools with their correct uses.
5. Match electricity-specific hand tools with their correct uses.
6. List three factors to consider when purchasing hand tools.
7. Select true statements concerning rules for care of various hand tools.
8. Demonstrate the ability to:
    a. Clean and lubricate an adjustable hand tool. (Job Sheet #1)
    b. Use a cutting-crimping tool. (Job Sheet #2)
    c. Adjust wire strippers. (Job Sheet #3)
    d. Set up and use a hacksaw. (Job Sheet #4)

OBJECTIVE SHEET

e. Cut rigid conduit with a pipe cutter. (Job Sheet #5)

f. Ream rigid conduit. (Job Sheet #6)

g. Bend EMT conduit. (Job Sheet #7)

h. Use a knockout punch. (Job Sheet #8)

i. Use a hole saw. (Job Sheet #9)

HAND TOOLS
UNIT IV

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Invite local suppliers to show various tools.
2. Visit local tool suppliers.
3. Demonstrate the proper use and care of hand tools.
4. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

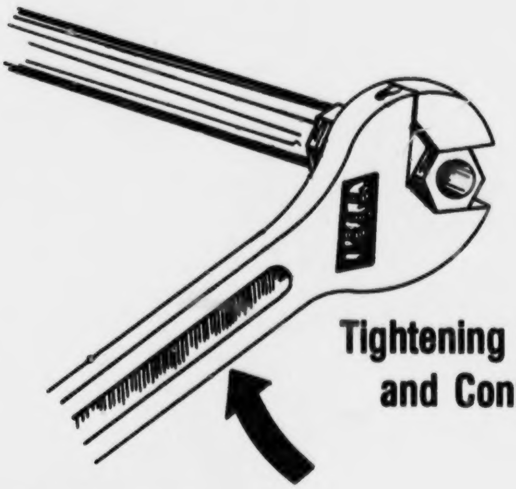
REFERENCES USED IN WRITING THIS UNIT

A. *Klein Tools Catalog*. Klein Tools, Inc., 7200 McCormick Blvd., Chicago, IL 60645. PH: (312) 677-9500.

B. Siebert, Leo N. *Introduction to Industrial Electricity-Electronics*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1981.

C. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

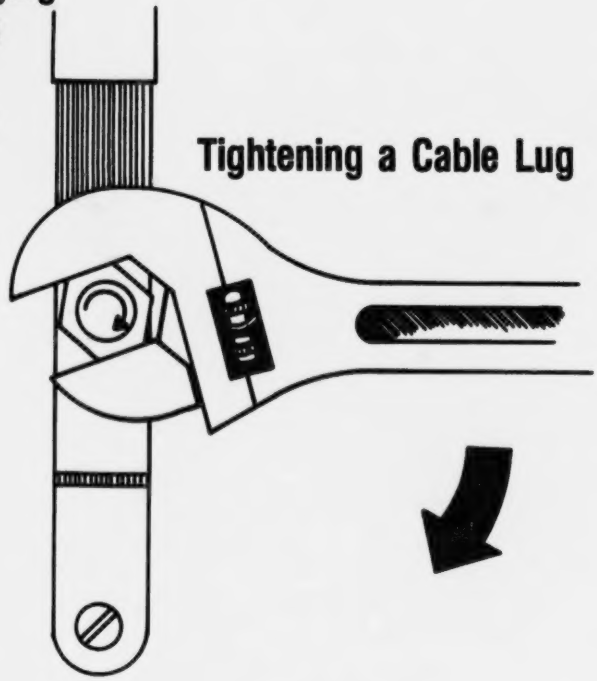
Using an Adjustable Wrench



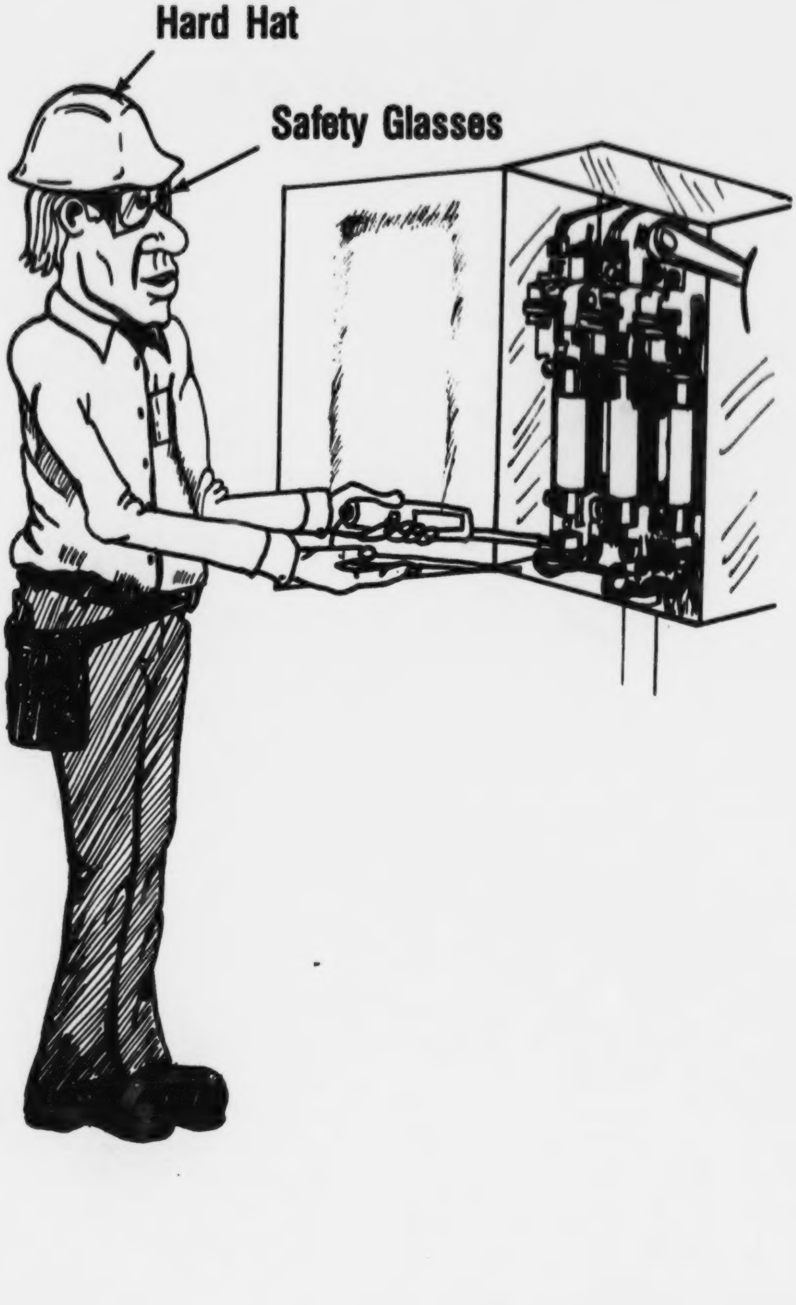
Tightening Couplings and Connectors

(NOTE: Always pull away from stationary jaw to avoid breaking or damaging wrench. Arrows indicate correct direction for wrenches in the current position.)

Tightening a Cable Lug



Using a Circuit Tester


Hard Hat
Safety Glasses

HAND TOOLS
UNIT IV

INFORMATION SHEET

I. **Terms and definitions**

A. Arbor — Shaft or spindle used to hold revolving cutting tool or the work to be cut

B. Cable-tie — Plastic straps with pull-through fasteners for binding together conductors or cables

C. Chuck — Device for holding a component of a tool rigid

D. Circuit box — Box where electrical connections are made, usually through circuit breakers

E. Conductor — Material through which electrons flow easily; used to connect components

F. Conduit — Pipe or tube which holds and protects wires or cables

G. Coupling — Mechanical device for connecting conduit and cabling

H. Fuse — Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

I. Heat shrink — Nonconductive material placed around a conductor for insulation; shrinks when heated

J. Insulation — Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

K. Live circuit — Circuit with voltage applied

L. Plasterboard — Thin board formed of layers of plaster and paper; Sheetrock

M. Print — Industrial blueprint; industrial wiring diagram

N. Snap ring — Metal ring which fastens around or in a shaft to keep other parts stationary

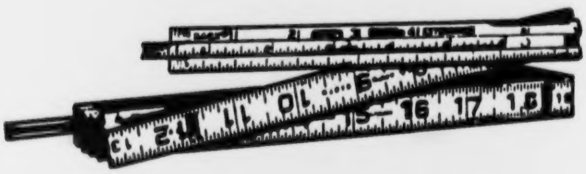
O. Spaghetti — Nonconductive material placed around a conductor for insulation; does not shrink

P. Wire lug — Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

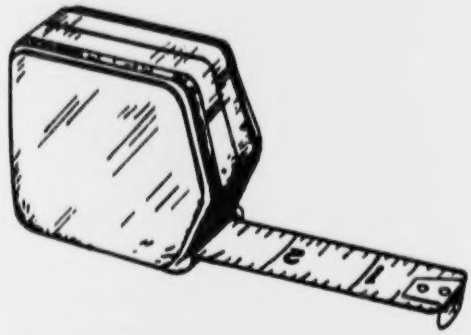
INFORMATION SHEET

II. Common hand tools used in the electrical field

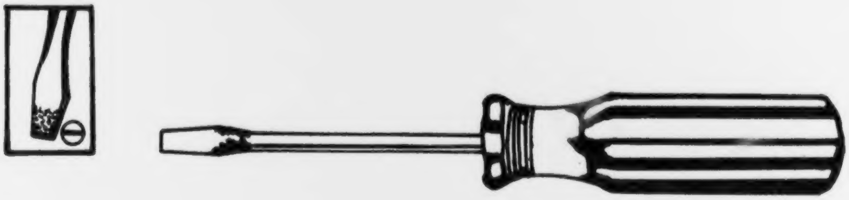
A. Folding rule



B. Tape measure

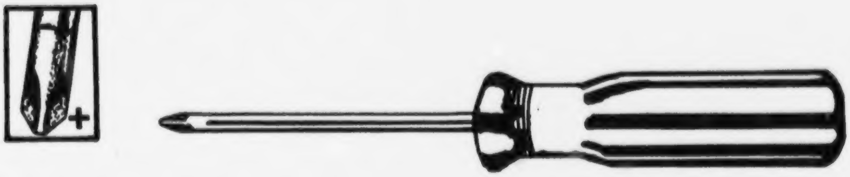


C. Flat-blade screwdriver

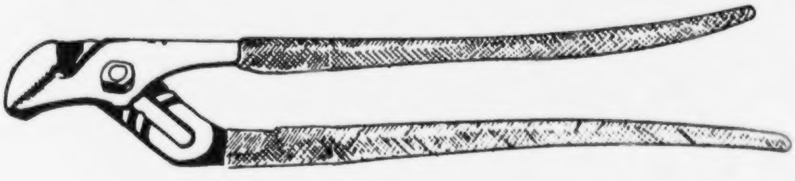


INFORMATION SHEET

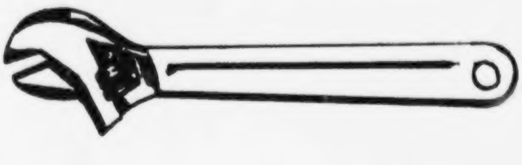
D. Phillips screwdriver



E. Pump pliers

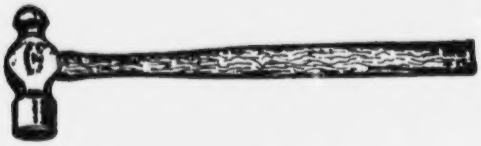


F. Adjustable wrench



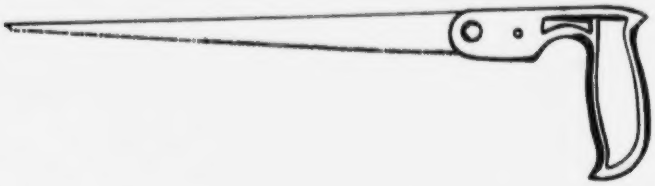
INFORMATION SHEET

G. Ball peen hammer



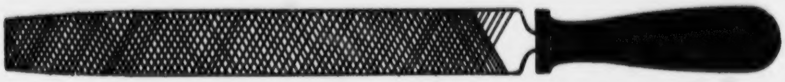
H. Hacksaw

I. Keyhole saw

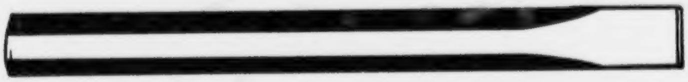


INFORMATION SHEET

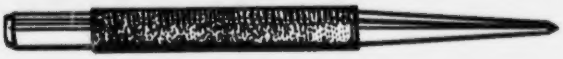
J. File



K. Chisel

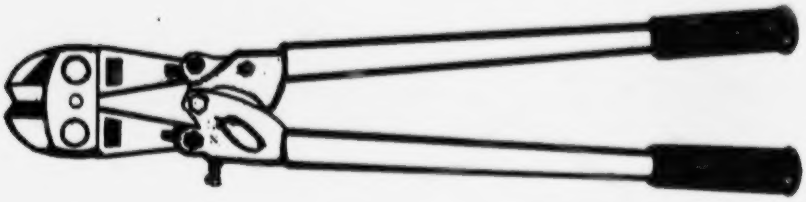


L. Center punch

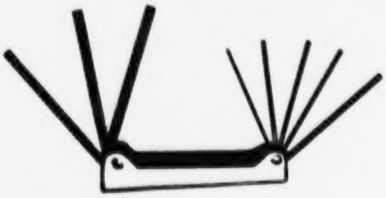


INFORMATION SHEET

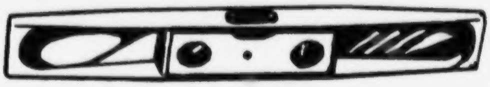
M. Bolt cutter



N. Hex key set (Allen wrenches)

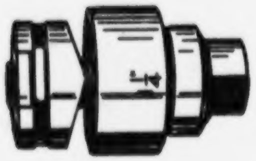


O. Magnetic torpedo level

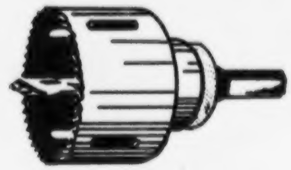


INFORMATION SHEET

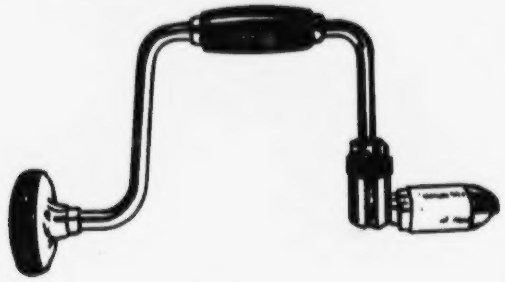
P. Knockout punch



Q. Hole saw and arbor

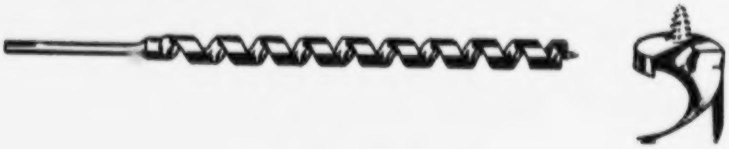


R. Drill brace

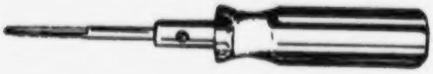


INFORMATION SHEET

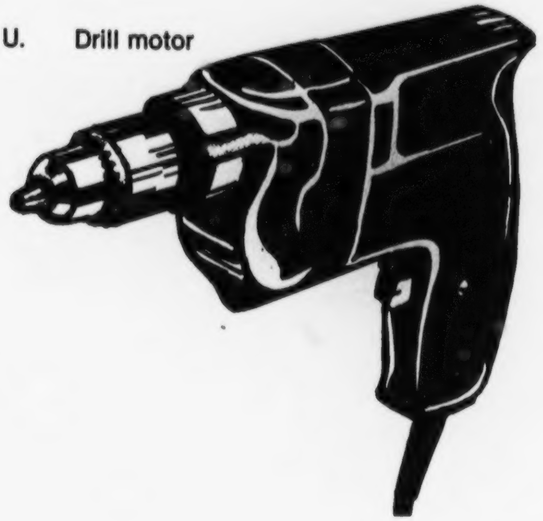
S. Ship auger drill bit



T. Tap tool



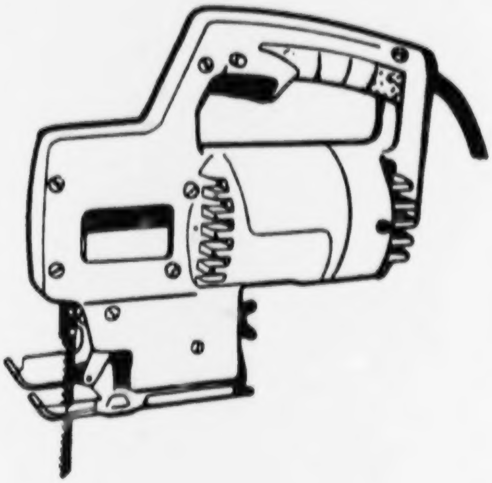
U. Drill motor



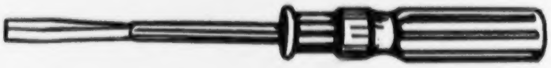
INFORMATION SHEET

V. Drill bit

W. Reciprocating saw



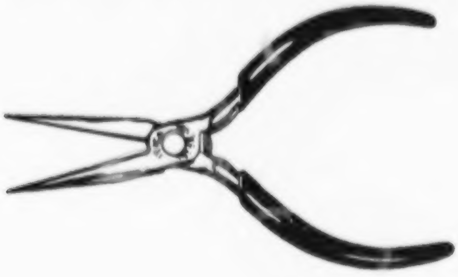
X. Screw-holding screwdriver



INFORMATION SHEET

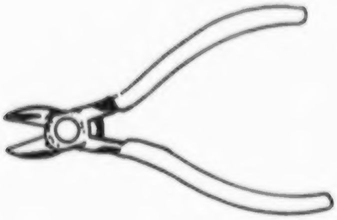
III. **Electricity-specific hand tools used in the electrical field**

A. Needle-nose pliers

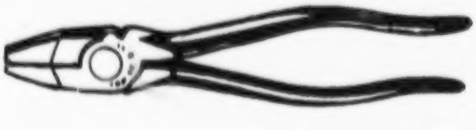


(NOTE: This tool is available with 12 AWG stripper.)

B. Diagonal pliers (dykes)

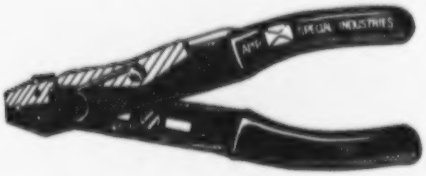


C. Lineman's pliers

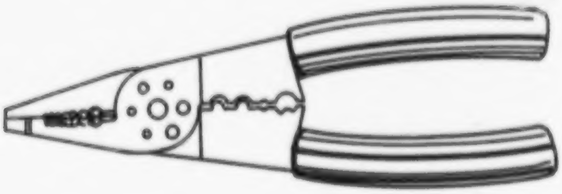


INFORMATION SHEET

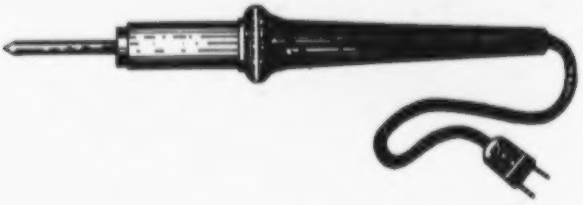
D. Adjustable wire stripper


AMP
SPECIAL INDUSTRIES

E. Cutting/crimping tool

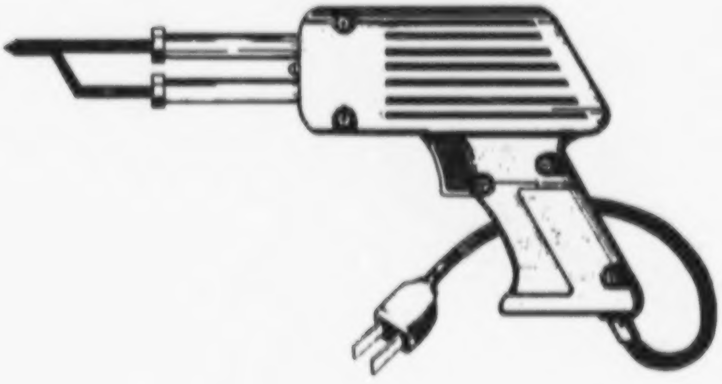


F. Soldering iron (approximately 25 W)

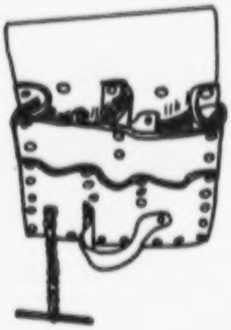


INFORMATION SHEET

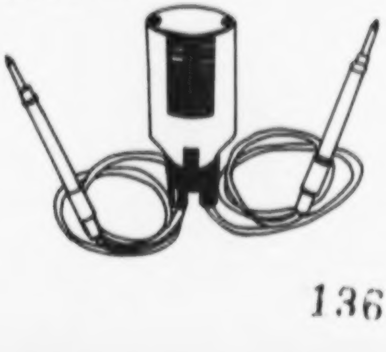
G. Soldering gun(250W)



H. Tool pouch

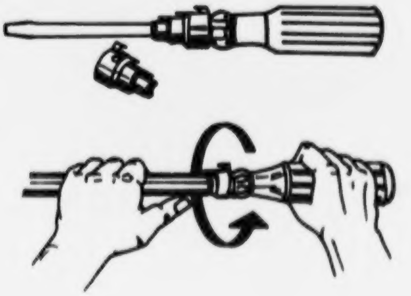


I. Circuit tester

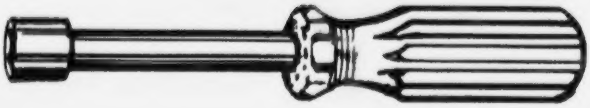


INFORMATION SHEET

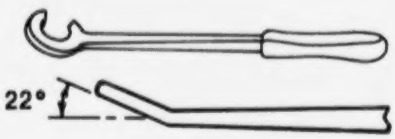
J. Conduit reamer



K. Nut driver

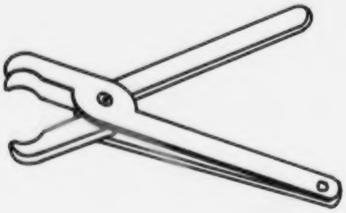


L. Cable benders

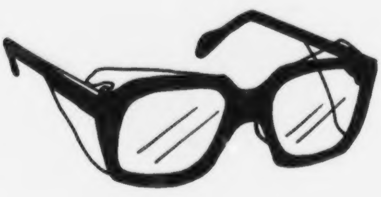


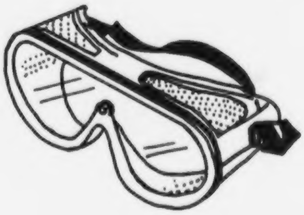
INFORMATION SHEET

M. Fuse puller

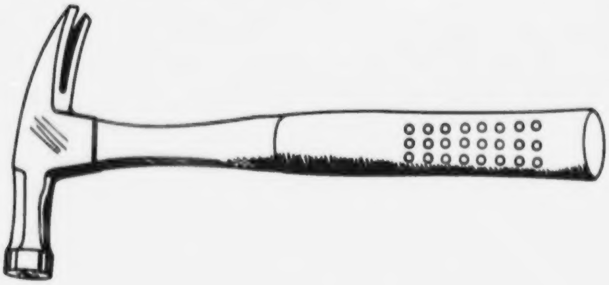


N. Safety glasses and goggles



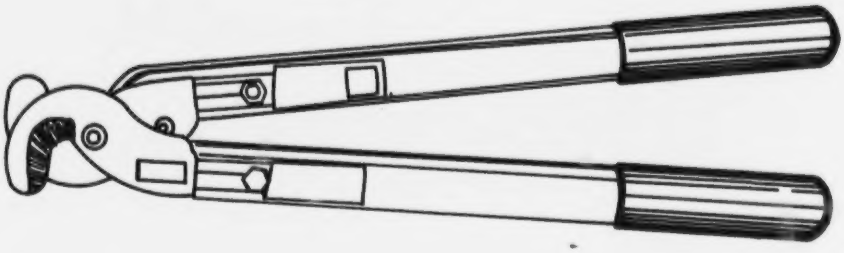


O. Electrician's hammer

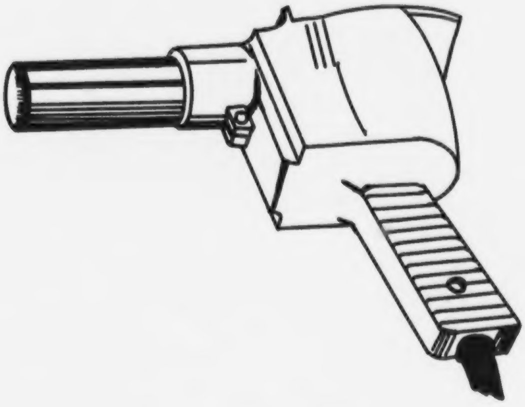


INFORMATION SHEET

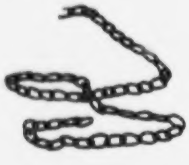
P. Cable cutter



Q. Heat gun

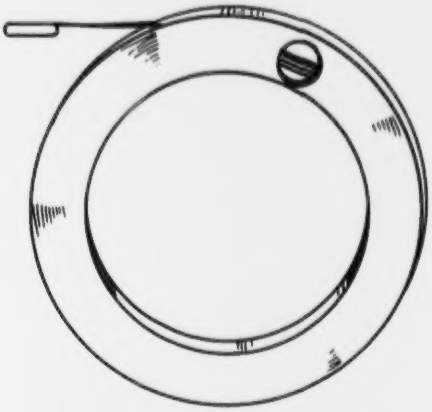


R. Drop chain

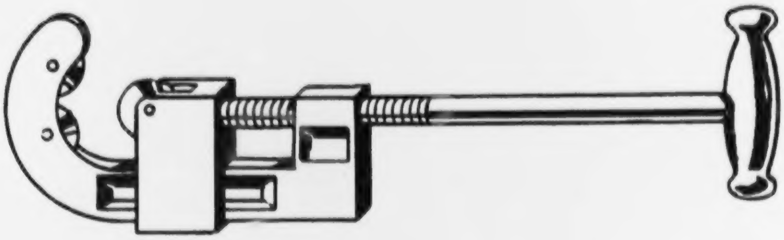


INFORMATION SHEET

S. Steel fish tape and reel

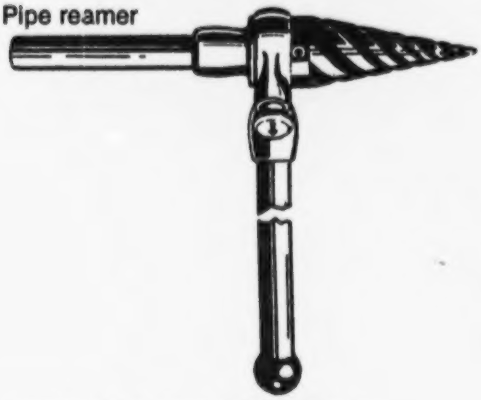


T. Pipe cutter

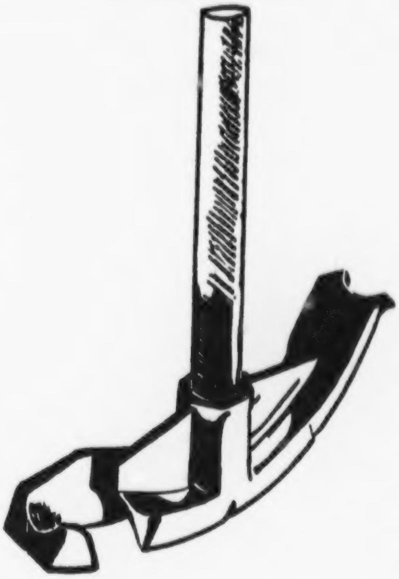


INFORMATION SHEET

U. Pipe reamer

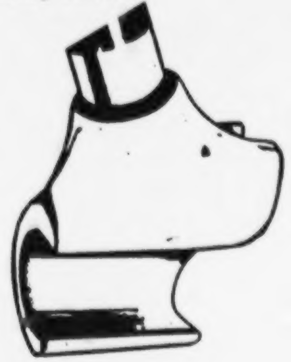


V. Combination conduit/EMT bender

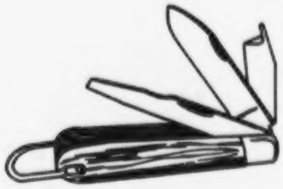


INFORMATION SHEET

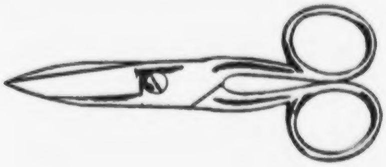
W. Hickey bender



X. Electrician's knife

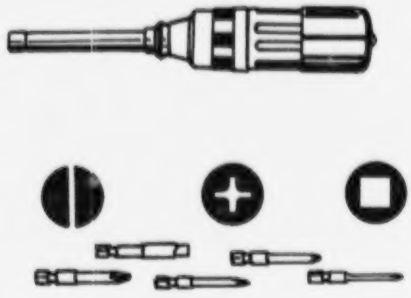


Y. Electrician's scissors

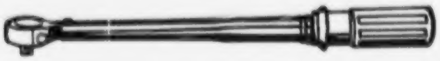


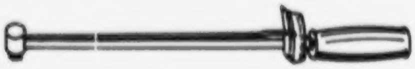
INFORMATION SHEET

Z. Torque screwdriver



AA. Torque wrenches





IV. **Common hand tools and their uses**

A. Folding rule or tape measure — Measures distances on prints, conduit, cable, and so forth

B. Flat-blade screwdriver — Installs and/or removes slot-head screws

C. Phillips screwdriver — Installs and/or removes Phillips-head screws

D. Pump pliers

1. Hold couplings and conductors
2. Tighten couplings and conductors
3. Hold conduit
4. Tighten or turn conduit

E. Adjustable wrench — Used in place of other wrenches; versatile

INFORMATION SHEET

F. Hacksaw

1. Cuts large conductors or cables
2. Cuts conduit
3. Cuts metal for electronic cabinets

G. Keyhole saw — Cuts holes in plasterboard for circuit boxes; needs no electric power

H. File

1. Deburrs large conduit
2. Sharpens tools
3. Deburrs holes in circuit boxes
4. Cleans soldering iron or soldering gun tips

I. Chisel — Notches wood for boxes or cables

J. Center punch — Makes center tap for drilling

K. Bolt cutter — Cuts large bolts, chains, locks, and so forth

L. Hex key set (Allen wrenches) — Installs and/or removes Allen screws

M. Magnetic torpedo level

1. Levels conduit
2. Levels equipment

N. Knockout punch — Cuts large holes in metal boxes without drilling

(NOTE: Thick or very hard metal cannot be cut with a knockout punch. Also, in some areas it is too inconvenient to use a knockout punch.)

O. Hole saw — Cuts large holes in metal

P. Drill brace and drill — Bores holes for conduit or cable

Q. Tap tool

1. Equips drill holes with bolt threads
2. Retaps damaged threads
3. Determines bolt size

INFORMATION SHEET

R. Drill motor and drill — Drills holes for electronic cabinets; needs electric power

S. Reciprocating saw — Cuts holes in plasterboard; needs electric power

T. Screw-holding screwdriver — Holds screw for use in limited-space installation

V. Electricity-specific hand tools and their uses

A. Needle-nose pliers

1. Form loops on small conductors
2. Cut small conductors
3. Hold conductors while soldering
4. Can have #12 AWG stripper

B. Diagonal pliers (dykes)

1. Cut small conductors
2. Cut conductors in limited space

C. Lineman's pliers

1. Cut large conductors
2. Form loops on large conductors
3. Pull and/or hold large conductors

D. Adjustable wire stripper

1. Strips insulation from conductors
2. Cuts small conductors

E. Cutting/crimping tool

1. Strips insulation from conductors
2. Cuts small conductors
3. Cuts small bolts
4. Crimps wire lugs

INFORMATION SHEET

F. Soldering iron (approximately 25 W)

   1. Solders small heat-sensitive components

   2. Solders on printed circuit boards

G. Soldering gun

   1. Solders large conductors

   2. Splices cables

H. Tool pouch

   1. Holds tools

   2. Keeps tools organized

I. Circuit tester

   1. Checks circuits for power

   2. Checks fuses and breakers

J. Conduit reamer — Reams burrs from cut conduits and EMT

K. Nut driver

   1. Installs and/or removes nuts and bolts

   2. Tightens or loosens nuts on long bolts

L. Cable bender — Assists in bending large cables

M. Fuse puller — Removes fuses safely from equipment and circuit panels

(NOTE: Fuse pullers are insulated in order to prevent shock, but power must be turned off first for safety.)

N. Safety glasses and goggles — Protect eyes from foreign objects or liquids

O. Electrician's hammer

   1. Drives and pulls nails

   2. Opens wooden crates

   3. Breaks plasterboard

P. Cable cutter — Cuts large cables

(NOTE: Cables must be either copper or aluminum.)

INFORMATION SHEET

Q. Heat gun

  1. Dries electronic components and/or conductors

  2. Shrinks heat shrink

R. Drop chain — Pulls cables through wall

S. Steel fish tape and reel

  1. Pulls conductors through conduit

  2. Pulls cables through insulated walls

T. Pipe cutter — Cuts conduit

U. Pipe reamer — Deburrs conduit

V. Conduit bender — Bends conduit for conductor installation

W. Hickey bender — Bends heavy conduit

X. Electrician's knife

  1. Opens paper cartons

  2. Strips large conductors

  3. Strips cables

  4. Tightens or loosens small screws when screwdriver is not available

  (NOTE: Some electrician's knives are equipped with screwdriver blades.)

Y. Electrician's scissors

  1. Cut small conductors

  2. Remove insulation from small conductors

  3. Cut paper, heat shrink, spaghetti, cable-tie, and so forth

Z. Torque screwdriver — Tightens slotted lugs and screws to manufacturer's torque specifications

AA. Torque wrenches — Tighten Allenhead and bolt type lugs to manufacturer's specifications

INFORMATION SHEET

VI. **Factors to consider when purchasing tools**

A. Size

(NOTE: Always purchase the correct sized tool for the work to be done.)

B. Design

EXAMPLES: Insulated handles, hammers with straight claws

(NOTE: Tool should be designed specifically for electrical work.)

C. Quality

(NOTE: The purchase of quality tools will save replacement cost.)

VII. **Rules for care of various hand tools**

(NOTE: All tools should be used only for the purpose intended.)

A. Screwdrivers

1. Discard worn or damaged flat-blade screwdrivers.
2. Discard Phillips screwdrivers with damaged tips.

B. Pliers

1. Keep clean and free of rust.
2. Keep cutting edges sharp.
3. Keep pliers working freely.
4. Replace damaged handle insulation.

C. Adjustable wrenches — Keep worm gears clean and lubricated.

D. Cutting tools

EXAMPLES: Saws, punches, chisels, drills, knives

1. Keep cutting edges sharp.
2. Protect cutting edges.
3. Keep tools clean and lubricated.

E. Electrically powered tools

1. Replace damaged cords.
2. Do not unplug by pulling cord.
3. Lubricate movable parts.
4. Keep clean.
5. Store properly.

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HAND TOOLS
UNIT IV

JOB SHEET #1 — CLEAN AND LUBRICATE AN ADJUSTABLE HAND TOOL

A. Equipment and materials needed

1. Pliers, or other adjustable hand tool
2. Solvent
3. Oil
4. Solvent tray

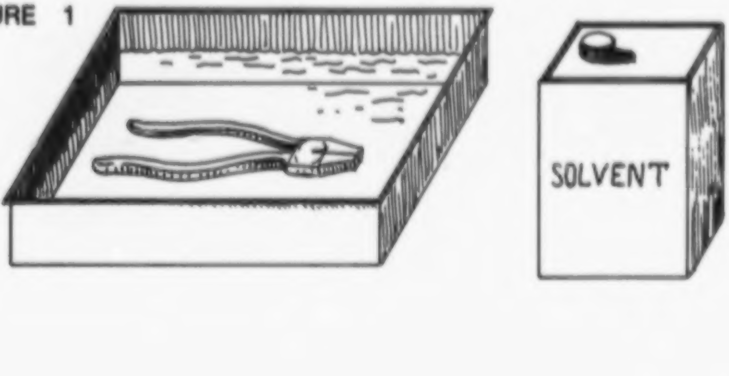
   (NOTE: An old rectangular cake pan works well.)
5. Protective gloves
6. Cleaning cloth
7. Safety glasses

B. Procedure

1. Put on protective gloves and safety glasses.
2. Lay pliers in tray.
3. Pour solvent into tray until pliers are submersed. (Figure 1)

   (NOTE: If pliers are equipped with cushion grips, only the head should be immersed.)

FIGURE 1



JOB SHEET #1

4. Open and close pliers several times while submersed.

5. Let pliers sit in solvent for two or three minutes.

6. Remove from solvent.

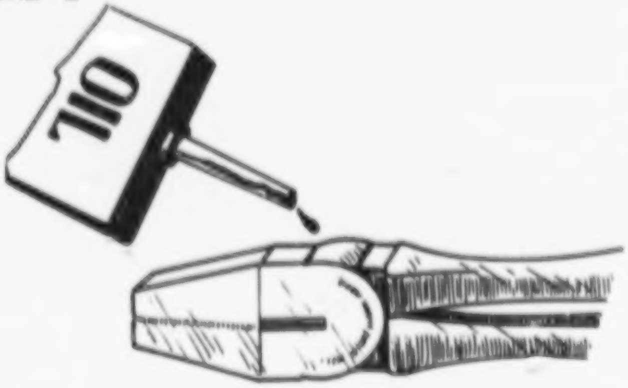
7. Open and close rapidly until pliers work freely.

   (NOTE: If pliers will not yet work, repeat steps B, C, D, and E.)

8. Wipe residue from plier joints with a cloth.

9. Apply a couple of drops of oil to joints, and work until oil has penetrated. (Figure 2)

FIGURE 2



10. Wipe excess oil from pliers.

    (NOTE: Have instructor check tool.)

11. Put away equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #2 — USE A CUTTING/CRIMPING TOOL

A. Equipment and materials needed

1. Cutting/crimping tool
2. Solid insulated conductor—12 to 18 gauge
3. Bolt—Size 6-32, 8-32, or 10-24, 10-32, 4-40
4. Wire lug—Same size as conductor
5. Safety glasses

B. Procedure

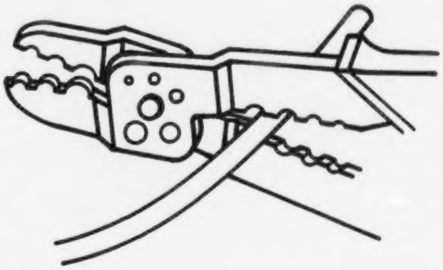
1. Examine cutting/crimping tool.
2. Locate stripping area of the cutting/crimping tool.
3. Locate correct-sized stripping slot for conductor.

   EXAMPLES: AWG-18, AWG-20 wire size

4. Put on safety glasses.
5. Open cutting/crimping tool and insert conductor into curved area of stripping slot. (Figure 1)

   (NOTE: Insert conductor approximately ¼ inch from end of conductor.)

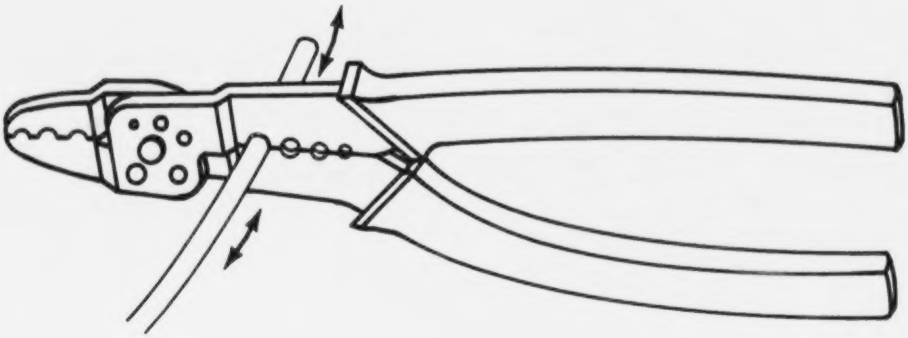
FIGURE 1



JOB SHEET #2

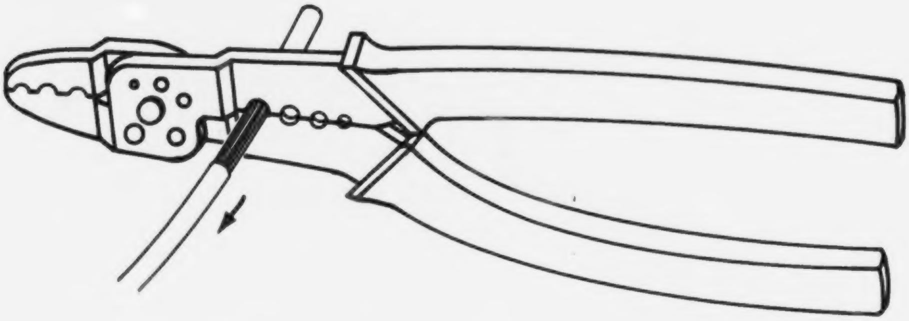
6. Slowly close cutting area by squeezing handles together. (Figure 2)

FIGURE 2



7. Pull conductor long lead away from cutting/crimping tool. (Figure 3)

FIGURE 3



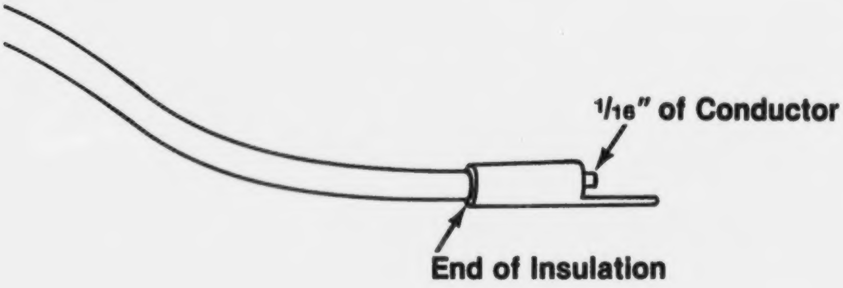
(NOTE: If the correct stripping slot was chosen, insulation should easily slide from the conductor. Have the instructor check your work.)

JOB SHEET #2

8. Put the wire lug on conductor. (Figure 4)

   (NOTE: The insulation should just touch the wire lug, and the bare conductor should protrude past the wire lug approximately one-sixteenth of an inch.)

FIGURE 4

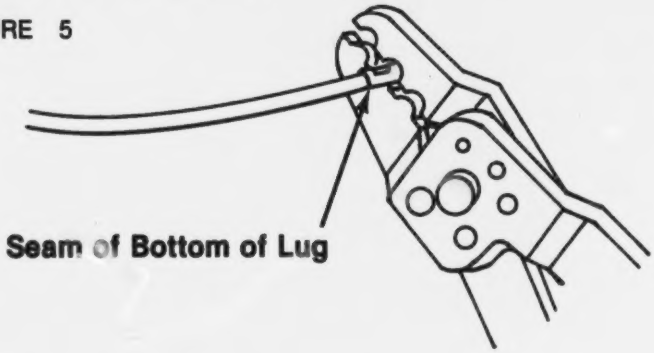

1/16" of Conductor
End of Insulation

9. Locate correct crimping area for size wire lug being used.

   (NOTE: The wire gauge number, the lug number, and the crimping tool number should all be the same. See Figure 5.)

10. Insert wire lug into crimping tool, making sure lug seam is on indenting side of crimping slot. (Figure 5)

FIGURE 5


Seam of Bottom of Lug

JOB SHEET #2

11. Squeeze the handles together.

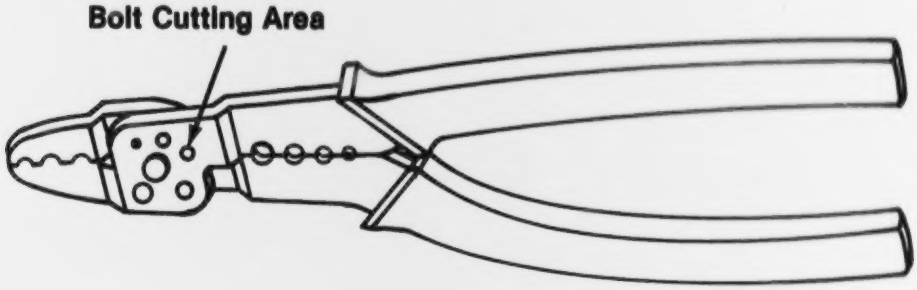
    (NOTE: This will crimp the wire lug onto the conductor.)

12. Remove cutting/crimping tool.

    (NOTE: Have instructor check your work.)

13. Locate bolt cutting area of cutting/crimping tool. (Figure 6)

FIGURE 6



14. Locate correct cutting slot for the bolt.

15. Screw bolt into cutting hole from the screw (threaded) side.

    (NOTE: On the cutting/crimping tool, one side is threaded and the other side is unthreaded.)

16. Screw the bolt into the cutting/crimping tool until desired length is at centerpoint of cutting tool.

17. Squeeze handles together until bolt is cut.

    (CAUTION: When bolt is cut, the unattached end may fly from cutter.)

18. Remove bolt from cutting/crimping tool.

    (NOTE: Have the instructor check your work.)

19. Put away equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #3 — ADJUST WIRE STRIPPERS

A. Equipment and materials needed

1. Adjustable wire strippers
2. Solid insulation conductor—12 or 14 gauge

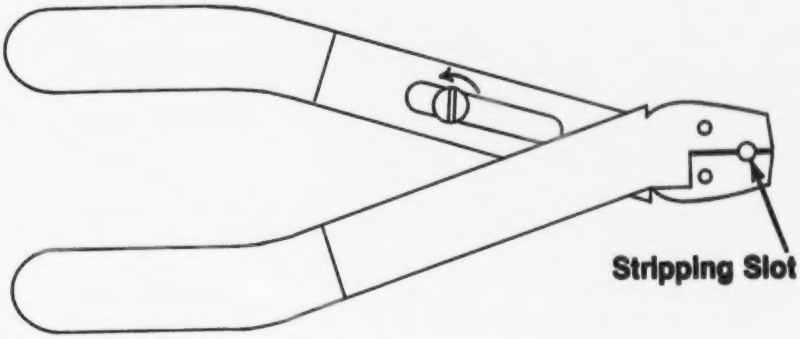
   (NOTE: Strippers should be adjusted for stripping the most commonly used conductor in your area.)

3. Screwdriver or nut driver to fit adjustment screw

B. Procedure

1. Loosen adjustment screw. (Figure 1)

FIGURE 1

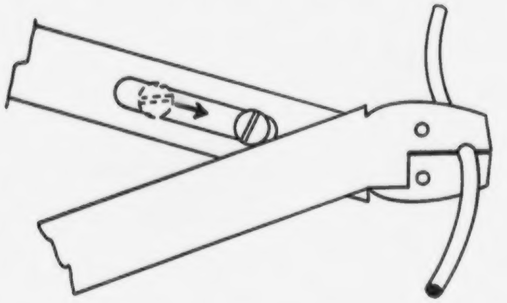


2. Insert conductor in stripping slot.
3. Close stripper jaws until you feel that you have reached the conductor.
4. Open the jaws slightly.

JOB SHEET #3

5. Slide adjustment screw down to its resting position. (Figure 2)

FIGURE 2

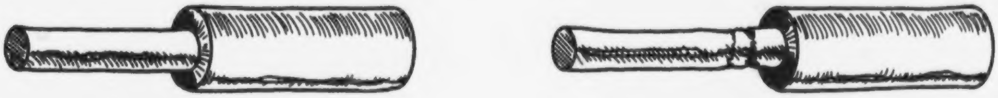


6. Strip off a fresh piece of insulation.

7. Check conductor for ring or nick. (Figure 3)

(NOTE: If nick occurs, loosen adjustment screw, move it back slightly, retighten, and test again until insulation is cut without conducter damage.)

FIGURE 3



Correctly Adjusted **Incorrectly Adjusted**

(NOTE: Have the instructor check your work.)

8. Put away equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #4 — SET UP AND USE A HACKSAW

A. Equipment and materials needed

1. Hacksaw frame
2. Hacksaw blade

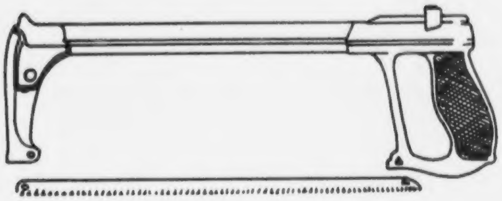
   (NOTE: For cutting pipe or conduit a 24 or 32 teeth/inch blade is recommended.)

3. Needle-nose pliers
4. Pipe or conduit
5. Safety glasses

B. Procedure

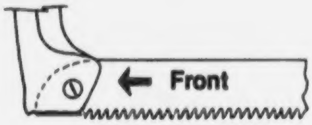
1. Put on safety glasses and gather tools and equipment.
2. Insert blade in frame. (Figure 1)

FIGURE 1



(NOTE: Be sure teeth angles are pointed toward the front of the saw. Figure 2.)

FIGURE 2

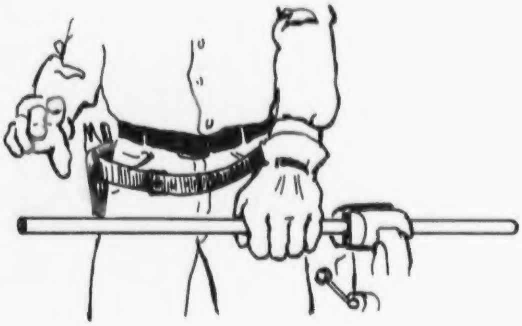


JOB SHEET #4

3. Secure pipe or conduit for cutting. (Figure 3)

   (NOTE: Short pieces of pipe are easier to cut in a vise.)

FIGURE 3



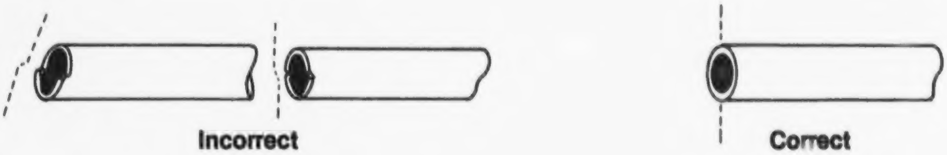
4. Rest blade on pipe or conduit at point to be cut.
5. Push forward gently until cut is started.

   (NOTE: Do not exert extra pressure on saw.)

6. Make reciprocal strokes until cut is finished.

   (NOTE: Excessive speed while cutting can ruin blades. Do not use over thirty full strokes per minute. Your cut should be straight and relatively smooth. Figure 4.)

FIGURE 4



   (NOTE: Have the instructor check your cut.)

7. Deburr cut end.
8. Put away equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #5 — CUT RIGID CONDUIT WITH A PIPE CUTTER

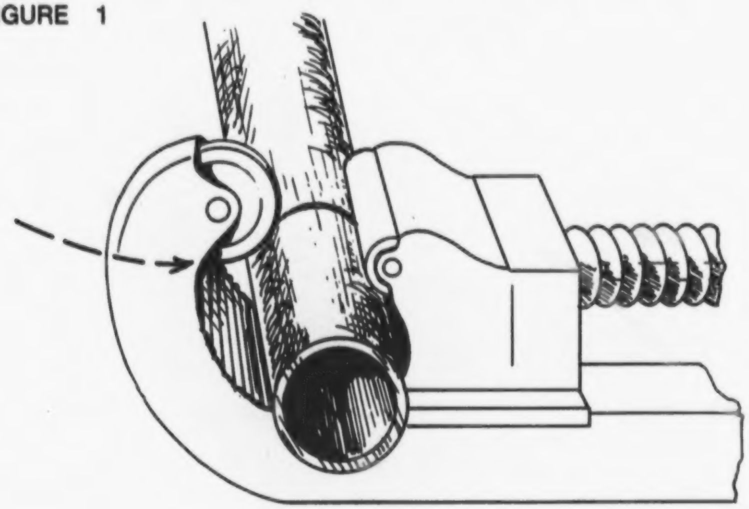
A. Equipment and materials needed

1. Pipe vise
2. Pipe cutter
3. Rigid conduit
4. Cutting oil
5. Safety glasses
6. Shop towel
7. Pencil

B. Procedure

1. Put on safety glasses and gather tools and equipment.
2. Secure conduit in vise.
3. Mark place for cut with pencil.
4. Open pipe cutter until it will fit over conduit.
5. Locate cutter wheel on the pencil mark. (Figure 1)

FIGURE 1

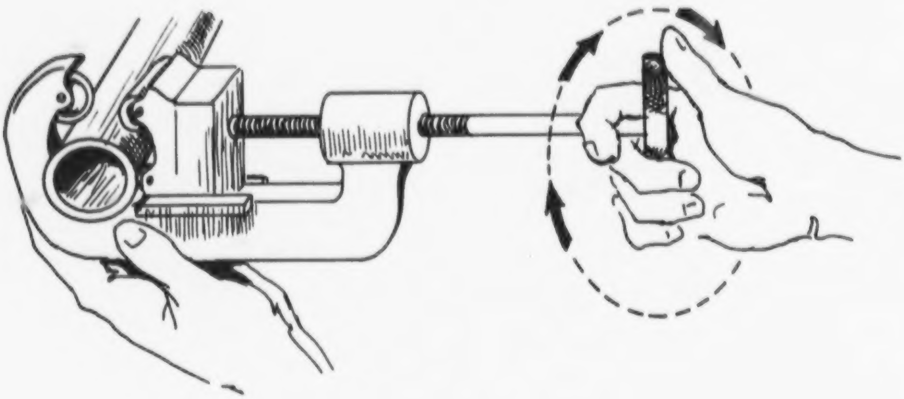


JOB SHEET #5

6. Snug cutter to conduit by rotating screw handle. (Figure 2)

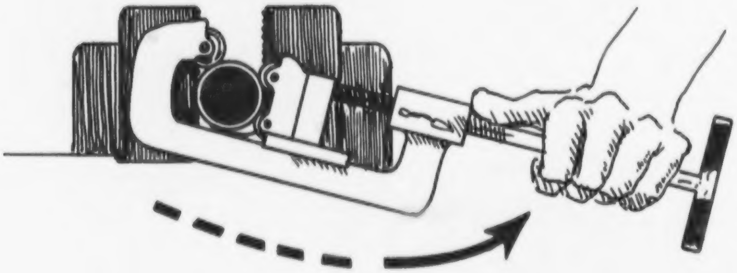
   (NOTE: Do not overtighten as this can break cutter wheel.)

FIGURE 2



7. Rotate cutter counterclockwise to start groove. (Figure 3)

FIGURE 3



8. Tighten cutter handle ¼ of a turn for each full revolution around the pipe.

   (NOTE: Overtightening can cause cutters to break.)

9. Add a small amount of cutting oil to the groove.

   (CAUTION: When cutting short pieces of conduit, be careful not to cut your arm while rotating the cutter around the pipe.)

JOB SHEET #5

10. Continue process until conduit is cut.

    (NOTE: Be prepared to catch free piece of conduit.)

11. Clean conduit and cutter with shop towel.

    (NOTE: Have instructor inspect work.)

12. Put away equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #6 — REAM RIGID CONDUIT

A. Equipment and materials needed

1. Pipe vise
2. Reamer

   (NOTE: You will need a ratchet hand or brace depending on which type reamer used.)

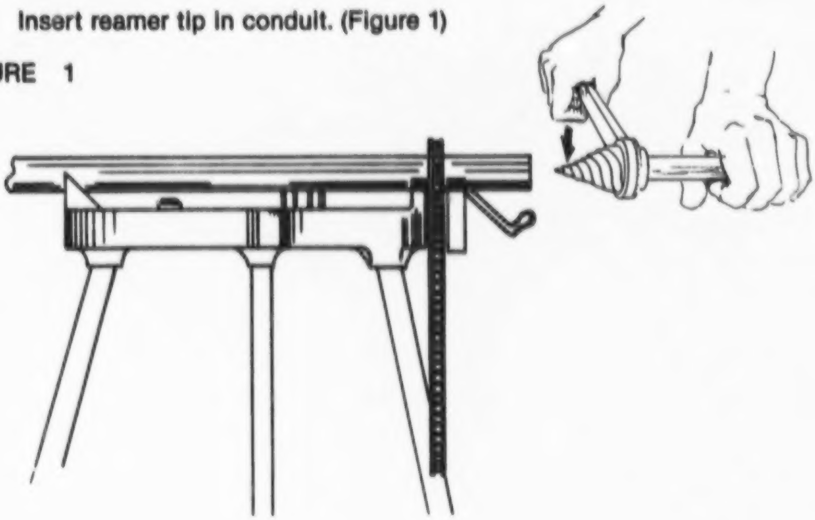
3. Piece of rigid conduit
4. Safety glasses

B. Procedure

(NOTE: Be safety conscious around cut pieces of rigid conduit. Sharp ridges or spurs can cause deep cuts.)

1. Place conduit in vise.
2. Insert reamer tip in conduit. (Figure 1)

FIGURE 1



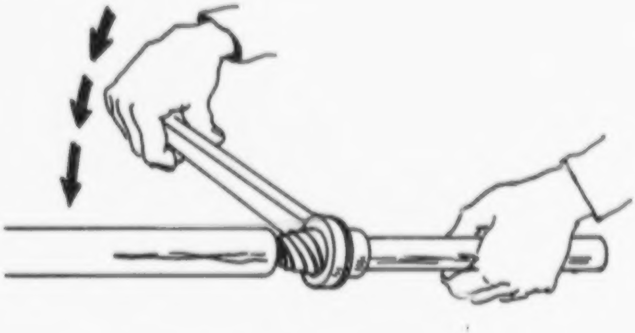
3. Apply light forward pressure to push reamer into conduit.

JOB SHEET #6

4. Start rotating reamer. (Figure 2)

   (NOTE: Reamer should bite instantly if proper pressure is applied. Reamer can be damaged if rotated in the wrong direction.)

FIGURE 2

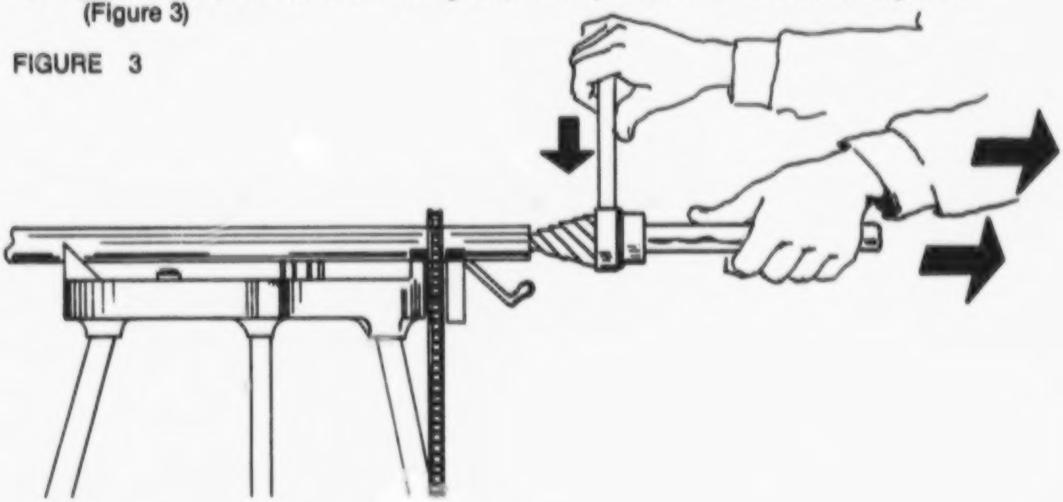


5. Rotate reamer until burrs are removed.

   (NOTE: This is a developed skill; the reamer can be pulled out and your progress inspected.)

6. Pull reamer back while continuing to rotate to prevent reamer from leaving a burr. (Figure 3)

FIGURE 3



(NOTE: Have your instructor check your work.)

7. Put away all equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #7 — BEND EMT CONDUIT

(NOTE: Because of the difference in bender shoe markings, the height of this bend and its determination will be left to the instructor.)

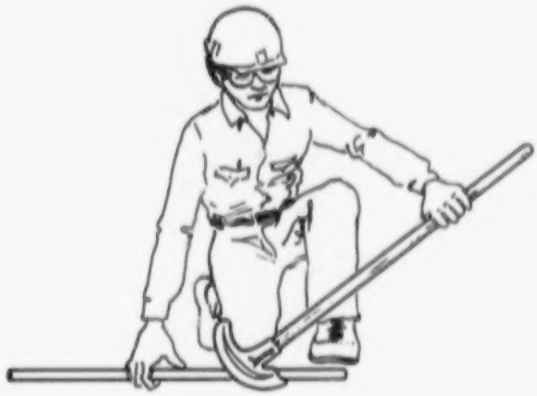
A. Equipment and materials needed

1. ½" EMT bender
2. ½" EMT (length optional)
3. Safety glasses

B. Procedure

1. Put on safety glasses and gather tools and equipment.
2. Place conduit in bender jaw. (Figure 1)

FIGURE 1

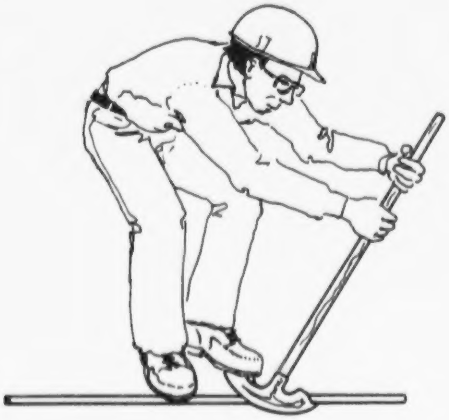


3. Apply light pressure on handle to hold conduit in place.
4. Place one foot on bender kick pad.

JOB SHEET #7

5. Place other foot on conduit. (Figure 2)

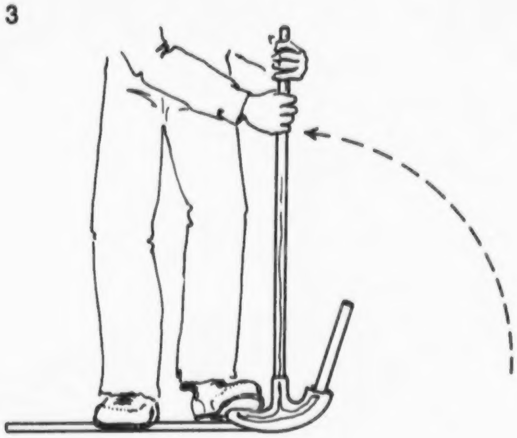
FIGURE 2



6. Apply heavy pressure on bender kick pad while pulling handle to a straight up position. (Figure 3)

   (NOTE: If pressure is not applied solidly to kick pad, conduit can wrinkle or collapse.)

FIGURE 3



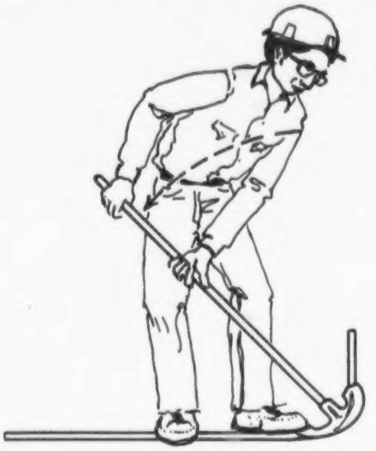
JOB SHEET #7

7. Reposition feet for comfort.

8. Reapply kick pad and bender handle pressure until bend is completed. (Figure 4)

   (NOTE: A square can be used to evaluate your accuracy until you develop your skills.)

FIGURE 4



(NOTE: Have instructor check your work.)

9. Put away all equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #8 — USE A KNOCKOUT PUNCH

A. Equipment and materials needed

1. Knockout punch
2. Drill motor
3. Metal drill

   (NOTE: Drill must be large enough to let the knockout punch bolt through the opening it makes.)

4. 10" adjustable wrench or ½" ratchet with socket to fit drive nut
5. Metal to be punched

   (NOTE: Most punches are rated up to 10 gauge metal.)

6. Vise

   (NOTE: A vise is needed if material to be cut is not fastened to a wall or is too small to stand on to hold.)

7. Safety glasses
8. Extension cord

B. Procedure

1. Put on safety glasses and gather materials and equipment.
2. In the center of the space you are going to punch, drill a hole slightly larger than the KO punch bolt.

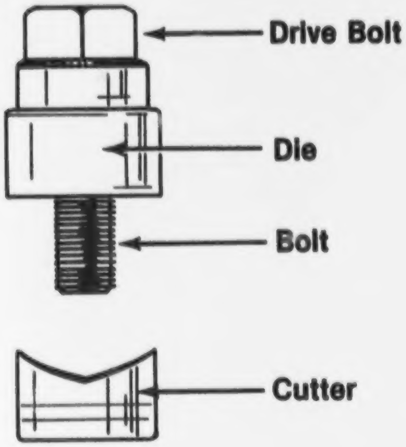
   (NOTE: A center punch should be used to make an indentation for your drill to start in.)

   (CAUTION: Hold the drill motor firmly while drilling. A loose grip could cause an accident. Remember that the drill will be hot; use caution around it until it cools.)

JOB SHEET #8

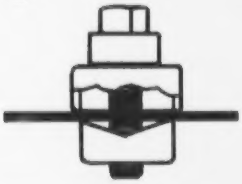
3. Separate the knockout punch cutter from the die and bolt. (Figure 1)

FIGURE 1


Drive Bolt
Die
Bolt
Cutter

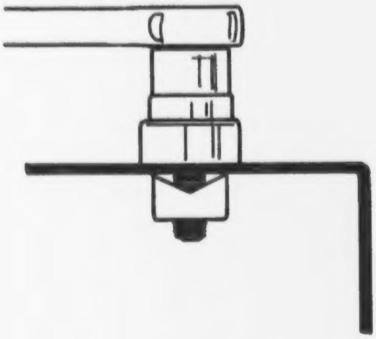
4. Insert bolt through drilled hole and put cutter back on screw. (Figure 2)

FIGURE 2



5. Tighten drive bolt with wrench or socket. (Figure 3)

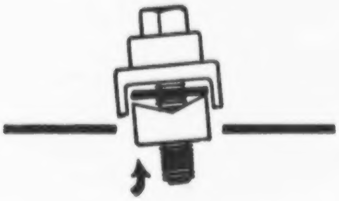
FIGURE 3



JOB SHEET #8

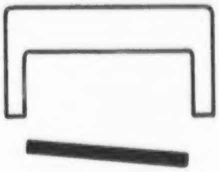
6. When cutter is finally pulled through, knockout punch is easily removed (Figure 4)

FIGURE 4



7. Remove cutter from bolt and shake out punched metal. (Figure 5)

FIGURE 5



8. Lubricate cutter, if needed, and replace.

   (NOTE: Have instructor check your work.)

9. Put away equipment and materials.

HAND TOOLS
UNIT IV

JOB SHEET #9 — USE A HOLE SAW

A. Equipment and materials needed

1. Hole saw and arbor—Size determined by instructor
2. Drill motor
3. Center punch
4. Metal to be cut

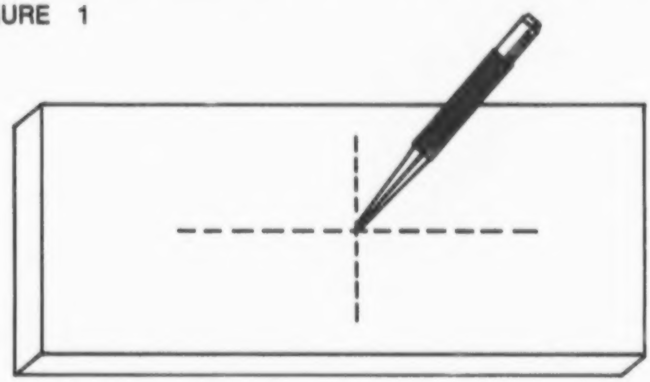
   (NOTE: Most hole saws can drill through any machinable material up to 1 1/8 inches thick.)

5. Safety glasses
6. Hammer

B. Procedure

1. Put on safety glasses.
2. Locate point on metal where hole is to be cut.
3. Place center punch on center point of hole to be cut. (Figure 1)

FIGURE 1



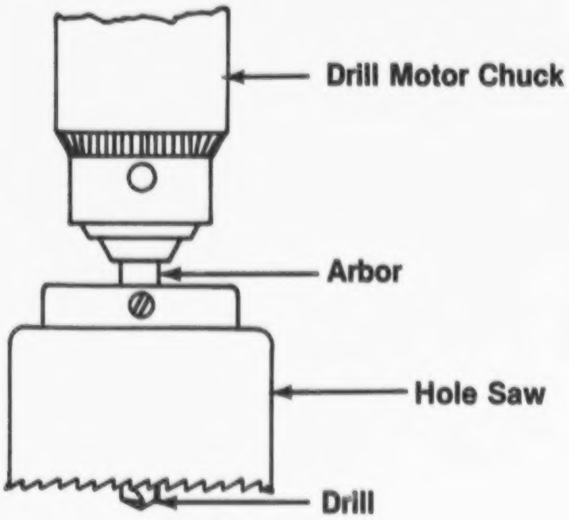
JOB SHEET #9

4. Strike center punch with hammer.

   (NOTE: How hard the center punch is struck is determined by the type and thickness of the metal being used. If struck too hard, softer, thinner metal will bend easily.)

5. Insert hole saw arbor into the drill motor chuck. (Figure 2)

FIGURE 2



   (CAUTION: Be sure chuck is tight, and chuck key is removed before drilling.)

6. Place tip of drill in hole made by the center punch.

   (NOTE: If material to be cut is not fastened solidly, put material in vise before cutting.)

   (CAUTION: While drilling, hold the drill motor firmly with both hands. The hole saw can become jammed causing the drill motor to spin.)

7. Turn on drill motor until hole saw has cut completely through metal being cut. Use cutting oil on heavy metal.

   (NOTE: Have instructor check your work.)

8. Put away equipment and materials.

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #1 — CLEAN AND LUBRICATE AN ADJUSTABLE HAND TOOL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Put on protective gloves.	______	______
4. Poured solvent in tray to cover pliers.	______	______
5. Opened and closed plier while immersed.	______	______
6. Wiped residue from plier joints.	______	______
7. Oiled plier joints.	______	______
8. Wiped excess oil from pliers.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Pliers clean	4	3	2	1
Pliers work freely	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #2 — USE A CUTTING/CRIMPING TOOL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Used correct stripping slot.	______	______
4. Used correct crimp connector.	______	______
5. Used correct cutting slot.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Bolt cut square	4	3	2	1
Threads true	4	3	2	1
Crimp sleeve properly installed and secure	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #3 — ADJUST WIRE STRIPPERS

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.		
2. Put on safety glasses.		
3. Adjusted stripper properly.		
4. Stripped conductor properly.		
5. Checked in/put away tools and materials.		
6. Cleaned the work area.		
7. Used proper tools correctly.		
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)		
9. Practiced safety rules throughout procedure.		
10. Provided satisfactory responses to questions asked.		

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Conductor is not scored				
	4	3	2	1
Approximately 3/8" stripped				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #4 — SET UP AND USE A HACKSAW

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Installed blade correctly.	______	______
4. Secured pipe or conduit for cutting.	______	______
5. Cut pipe straight.	______	______
6. Deburred cut end.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Blade teeth slope away from handle	4	3	2	1
Cut at 90° angle	4	3	2	1
Cut end deburred	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #5 — CUT RIGID CONDUIT WITH A PIPE CUTTER

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Secured conduit in vise properly.	______	______
4. Adjusted cutter properly.	______	______
5. Made cut properly.	______	______
6. Cleaned conduit and cutter with shop towel.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #5 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Made proper cut on conduit				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #6 — REAM RIGID CONDUIT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Placed conduit in vise properly.	______	______
4. Reamed conduit properly.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #6 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Reamed conduit and removed burrs				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #7 — BEND EMT CONDUIT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Placed EMT in jaw properly.	______	______
4. Used proper foot placement.	______	______
5. Used solid foot pressure on kick pad and reapplied until bend completed.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #7 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Accomplished 90° bend	4	3	2	1
No crimps in pipe	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #8 — USE A KNOCKOUT PUNCH

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Center punched hole.	______	______
4. Drilled proper size hole.	______	______
5. Operated knockout punch properly.	______	______
6. Lubricated cutter as needed.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #8 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Cut clean	4	3	2	1
Cut proper size	4	3	2	1
Cut in proper location	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

PRACTICAL TEST
JOB SHEET #9 — USE A HOLE SAW

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Center punched properly.	______	______
4. Tightened drill chuck securely.	______	______
5. Cut hole completely through metal.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #9 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Hole cut cleanly	4	3	2	1
Hole proper size	4	3	2	1
Hole in proper location	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HAND TOOLS
UNIT IV

TEST

NAME ________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

_____a. Industrial blueprint; industrial wiring diagram

_____b. Circuit with voltage applied

_____c. Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

_____d. Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

_____e. Device for holding a component of a tool rigid

_____f. Nonconductive material placed around a conductor for insulation; does not shrink

_____g. Box where electrical connections are made, usually through circuit breakers

_____h. Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

_____i. Pipe or tube which holds and protects wires or cables

_____j. Shaft or spindle used to hold a revolving cutting tool or the work to be cut

_____k. Nonconductive material placed around a conductor for insulation; shrinks when heated

_____l. Metal ring which fastens around or in a shaft to keep other parts stationary

1. Arbor
2. Cable-tie
3. Chuck
4. Circuit box
5. Conductor
6. Conduit
7. Coupling
8. Fuse
9. Heat shrink
10. Insulation
11. Live circuit
12. Plasterboard
13. Print
14. Snap ring
15. Spaghetti
16. Wire lug

TEST

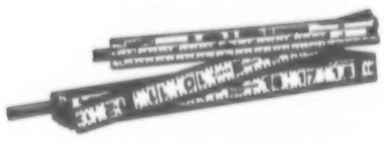
_____m. Mechanical device for connecting conduit and cabling

_____n. Material through which electrons flow easily; used to connect components

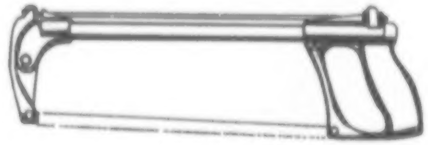
_____o. Plastic straps with pull-through fasteners for binding together conductors or cables

_____p. Thin board formed of layers of plaster and paper; Sheetrock

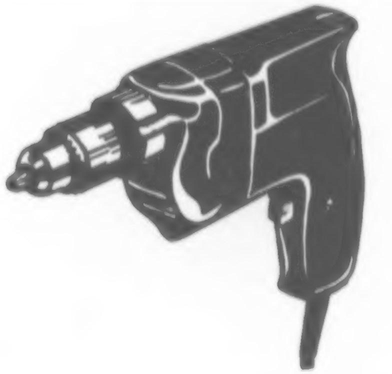
2. Label the following common hand tools used in the electrical field. Write the correct names in the spaces provided.



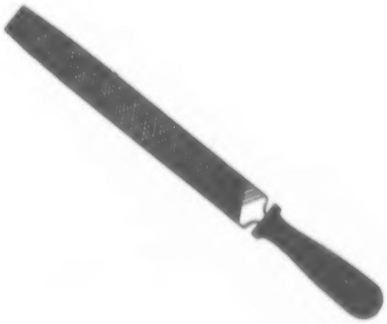
a. ______________________________



b. ______________________________

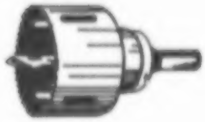


c. ______________________________

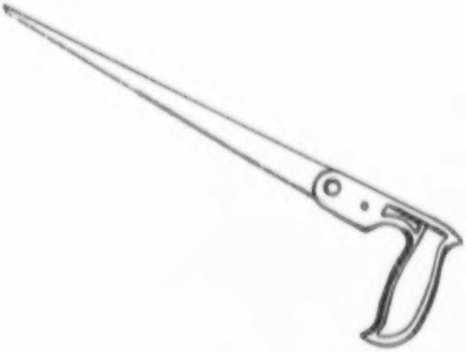


d. ______________________________

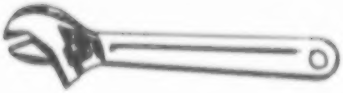
TEST



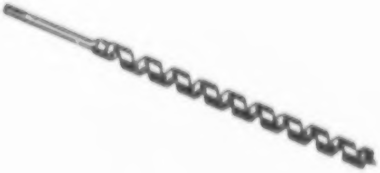
e. ______________________



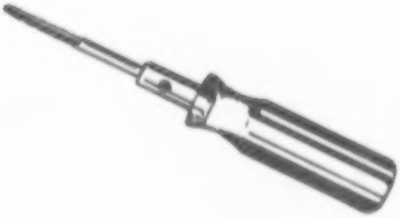
f. ______________________



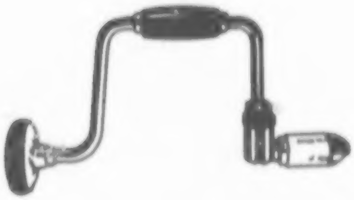
g. ______________________



h. ______________________

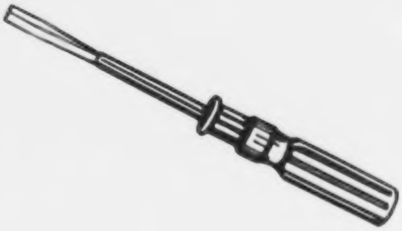


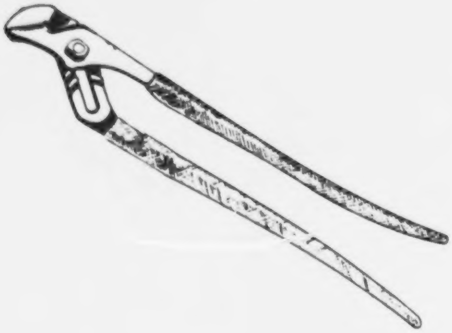
i. ______________________



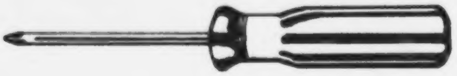
j. ______________________

TEST

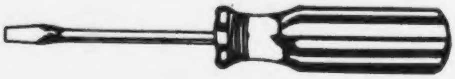


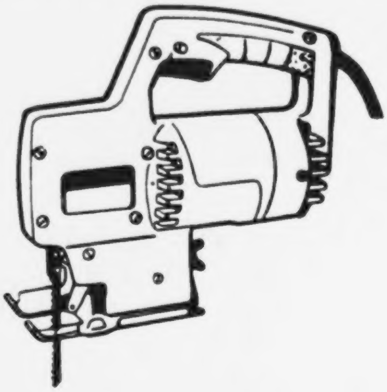


k. ______________________________ l. ______________________________



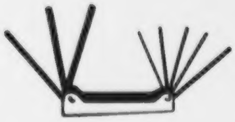
m. ______________________________ n. ______________________________



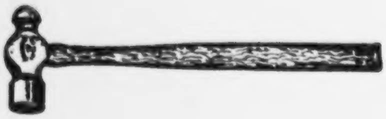


o. ______________________________ p. ______________________________

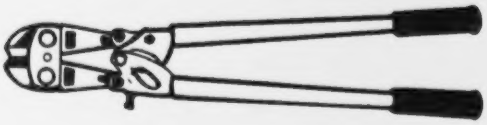
TEST



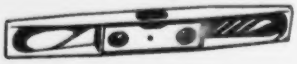
q. ______________________________



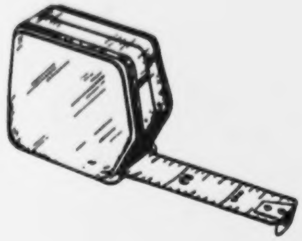
r. ______________________________



s. ______________________________



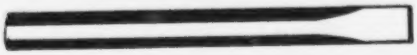
t. ______________________________

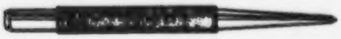


u. ______________________________

v. ______________________________

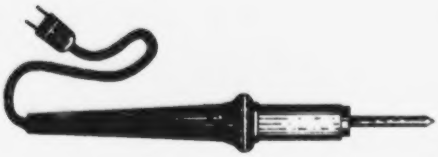
TEST

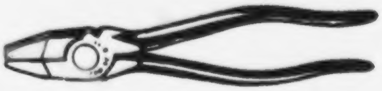




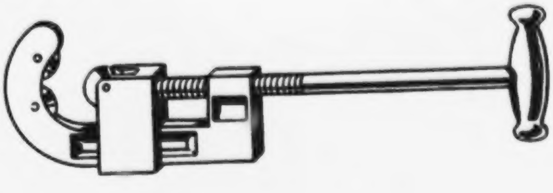
w. ______________________ x. ______________________

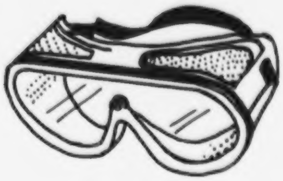
3. Label the following electricity-specific hand tools used in industrial maintenance. Write the correct names in the spaces provided.





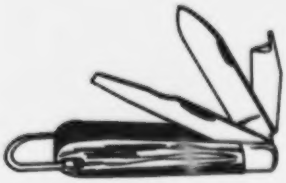
a. ______________________ b. ______________________

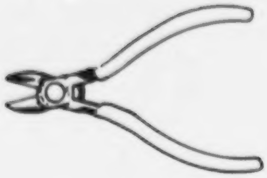




c. ______________________ d. ______________________

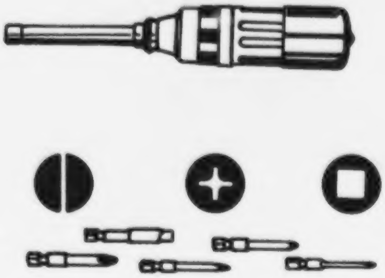
TEST

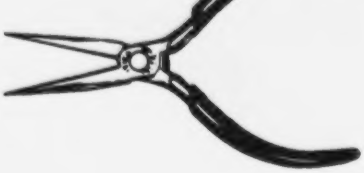




e. ______________________________

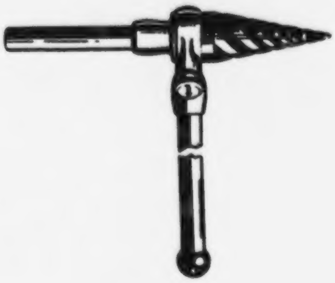
f. ______________________________

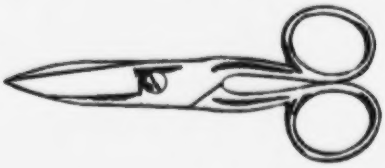




g. ______________________________

h. ______________________________

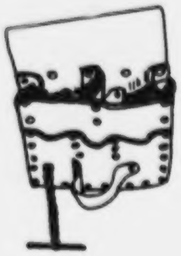




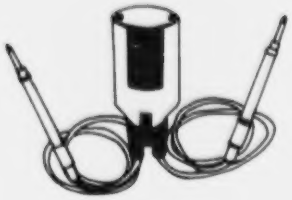
i. ______________________________

j. ______________________________

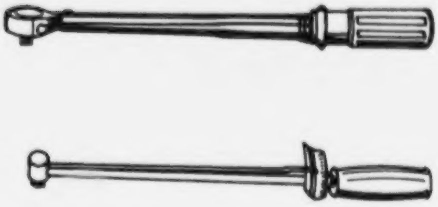
TEST



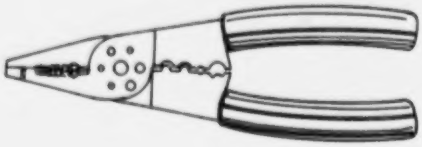
k. ______________________________



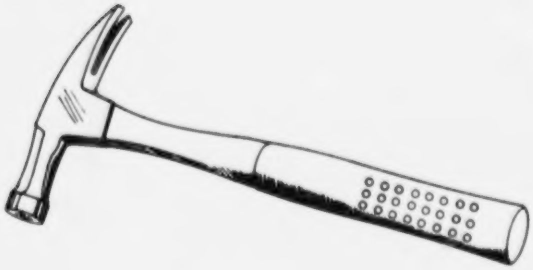
l. ______________________________



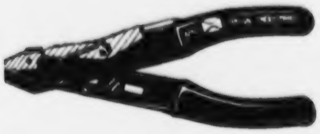
m. ______________________________



n. ______________________________

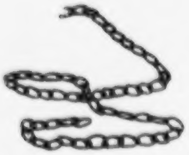


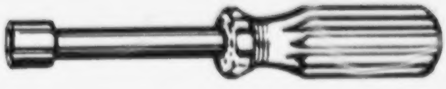
o. ______________________________



p. ______________________________

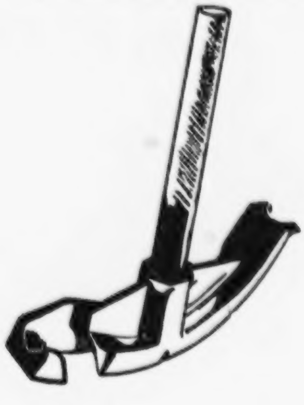
TEST

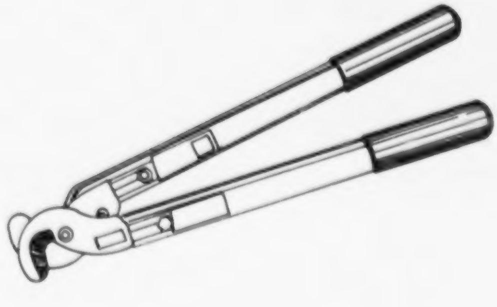




q. ______________________________

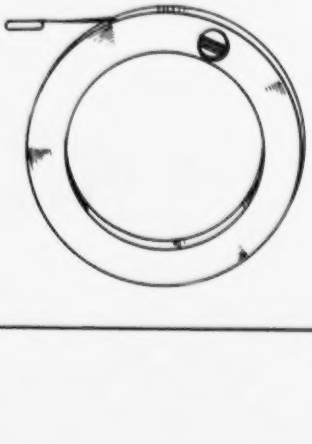
r. ______________________________

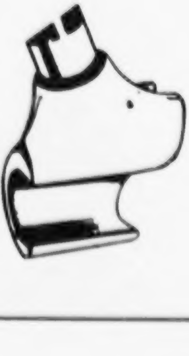




s. ______________________________

t. ______________________________

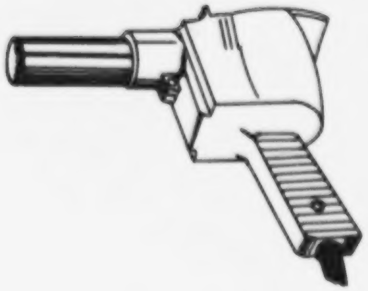




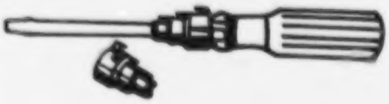
u. ______________________________

v. ______________________________

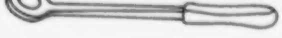
TEST



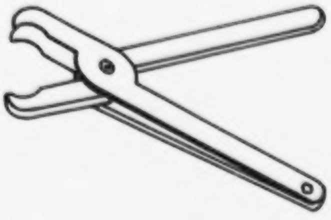
w. ______________________________



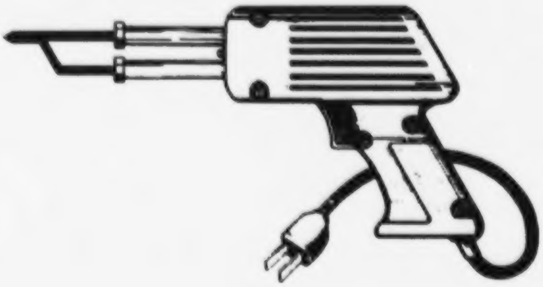
x. ______________________________



y. ______________________________



z. ______________________________



aa. ______________________________

TEST

4. Match common hand tools on the right with their correct uses. Write the correct numbers in the blanks. Some numbers may be used more than once. Uses are continued on the next page.

_____a. Cuts holes in plasterboard; needs electric power

_____b. Makes center tap for drilling

_____c. Cuts large holes in metal boxes without drilling

_____d. Installs and/or removes slot-head screws

_____e. Hold couplings and conductors

_____f. Cuts large conductor or cables

_____g. Cleans soldering iron or soldering gun tips

_____h. Equips drill holes with bolt threads

_____i. Drills holes for electronic cabinets; needs electric power

_____j. Holds screws for use in limited-space installation

_____k. Bores holes for conduit or cable

_____l. Cuts large bolts, chains, locks, and so forth

_____m. Levels conduit

_____n. Measures distances on prints, conduit, cable, and so forth

_____o. Installs and/or removes Phillips-head screws

_____p. Tightens or turns conduit

_____q. Cuts metal for electronic cabinets

_____r. Cuts holes in plasterboard for circuit boxes; needs no electric power

_____s. Deburrs large conduit

1. Folding rule or tape measure
2. Flat-blade screwdriver
3. Phillips screwdriver
4. Pump pliers
5. Adjustable wrench
6. Hacksaw
7. Keyhole saw
8. File
9. Chisel
10. Center punch
11. Bolt cutter
12. Hex key set (Allen wrenches)
13. Magnetic torpedo level
14. Knockout punch
15. Hole saw
16. Drill brace and drill
17. Tap tool
18. Drill motor and drill
19. Reciprocating saw
20. Screw-holding screwdriver

TEST

______t. Cuts conduit

______u. Installs and/or removes Allen screws

______v. Cuts large holes in metal

______w. Levels equipment

______x. Retaps damaged threads

______y. Notches wood for boxes or cables

______z. Determines bolt size

______aa. Sharpens tools

______bb. Tighten couplings and connectors

______cc. Used in place of other wrenches; versatile

______dd. Deburrs holes in circuit boxes

______ee. Hold conduit

5. Match electricity-specific hand tools on the right with their correct uses. Write the correct numbers in the blanks. Some numbers may be used more than once. Tools and uses are continued on the next page.

______a. Cut(s) small conductors

______b. Deburrs conduit

______c. Drives and pulls nails

______d. Shrinks heat shrink

______e. Removes fuses safely from equipment and circuit panels

______f. Cuts small bolts

______g. Reams burrs from EMT

______h. Splices cables

______i. Crimps wire lugs

1. Needle-nose pliers
2. Diagonal pliers (dykes)
3. Lineman's pliers
4. Adjustable wire stripper
5. Cutting/crimping tool
6. Soldering iron (approximately 25 W)
7. Soldering gun
8. Cable bender
9. Conduit reamer

TEST

______j. Pulls cables through wall

______k. Pulls cables through insulated walls

______l. Bends conduit for conductor installation

______m. Installs and/or removes nuts and bolts

______n. Opens wooden crates

______o. Bends heavy conduit

______p. Cuts conduit

______q. Cut paper, heat shrink, spaghetti, cable-tie, and so forth

______r. Form loops on small conductors

______s. Cut large conductors

______t. Strips insulation from conductors

______u. Solders large conductors

______v. Opens paper cartons

______w. Bends large cables

______x. Strips large conductors

______y. Holds conductors while soldering

______z. Protects eyes from foreign objects and liquids

______aa. Tightens or loosens nuts on long bolts

______bb. Checks circuits for power

______cc. Cuts large cables

______dd. Pulls conductors through conduit

______ee. Dries electronic components and/or conductors

(NOTE: Uses are continued on the next page.)

10. Safety glasses and goggles
11. Nut driver
12. Torque screwdriver
13. Circuit tester
14. Electrician's hammer
15. Cable cutter
16. Heat gun
17. Torque wrenches
18. Steel fish tape and reel
19. Pipe cutter
20. Pipe reamer
21. Conduit bender
22. Hickey bender
23. Electrician's scissors
24. Electrician's knife
25. Drop chain
26. Fuse puller

TEST

_____ff. Tightens or loosens small screws when a screwdriver is not available

_____gg. Breaks plasterboard

_____hh. Solders small heat-sensitive components

_____ii. Form loops on large conductors

_____jj. Tighten Allen head and bolt type lugs to manufacturer's specifications

_____kk. Solders on printed circuit boards

_____ll. Cut conductors in limited space

_____mm. Pull and/or hold large conductors

_____nn. Tightens slotted lugs and screws to manufacturer's specifications

6. List three factors to consider when purchasing hand tools.

a. ______________________________

b. ______________________________

c. ______________________________

7. Select true statements concerning rules for care of various hand tools by placing an "X" in the blanks preceding the true statements.

_____a. Discard worn or damaged flat-blade screwdrivers.

_____b. Keep pliers clean and free of rust.

_____c. Do not lubricate worm gears on adjustable wrenches.

_____d. Leave cutting edges exposed on cutting tools.

_____e. Discard electrically powered tools with damaged cords.

_____f. Do not unplug electrically powered tools by pulling cord.

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

8. Demonstrate the ability to:

   a. Clean and lubricate an adjustable hand tool. (Job Sheet #1)

   b. Use a cutting/crimping tool. (Job Sheet #2)

   c. Adjust wire strippers. (Job Sheet #3)

   d. Set up and use a hacksaw. (Job Sheet #4)

   e. Cut rigid conduit with a pipe cutter. (Job Sheet #5)

   f. Ream rigid conduit. (Job Sheet #6)

   g. Bend EMT conduit. (Job Sheet #7)

   h. Use a knockout punch. (Job Sheet #8)

   i. Use a hole saw. (Job Sheet #9)

HAND TOOLS
UNIT IV

ANSWERS TO TEST

1. a. 13
   b. 11
   c. 16
   d. 10
   e. 3
   f. 15
   g. 4
   h. 8
   i. 6
   j. 1
   k. 9
   l. 14
   m. 7
   n. 5
   o. 2
   p. 12

2. a. Folding rule
   b. Hacksaw
   c. Drill motor
   d. File
   e. Hole saw and arbor
   f. Keyhole saw
   g. Adjustable wrench
   h. Ship augar drill bit
   i. Tap tool
   j. Drill brace
   k. Screw-holding screwdriver
   l. Pump pliers
   m. Phillips screwdriver
   n. Drill bit
   o. Flat-blade screwdriver
   p. Reciprocating saw
   q. Hex key set (Allen wrenches)
   r. Ball peen hammer
   s. Bolt cutter
   t. Magnetic torpedo level
   u. Tape measure
   v. Knockout punch
   w. Chisel
   x. Center punch

3. a. Soldering iron (approximately 25 W)
   b. Lineman's pliers
   c. Pipe cutter
   d. Safety glasses
   e. Electrician's knife
   f. Diagonal pliers
   g. Torque screwdriver
   h. Needle-nose pliers
   i. Electrician's scissors
   j. Pipe reamer
   k. Tool pouch
   l. Circuit tester
   m. Torque wrenches
   n. Cutting/crimping tool
   o. Electrician's hammer
   p. Adjustable wire strippers
   q. Drop chain
   r. Nut driver
   s. Combination conduit/EMT bender
   t. Cable cutter
   u. Steel fish tape and reel
   v. Hickey bender
   w. Heat gun
   x. Conduit reamer
   y. Cable bender
   z. Fuse puller
   aa. Soldering gun

ANSWERS TO TEST

4.
a. 19
b. 10
c. 14
d. 2
e. 4
f. 6
g. 8
h. 17
i. 18
j. 20
k. 16
l. 11
m. 13
n. 1
o. 3
p. 4
q. 6
r. 7
s. 8
t. 6
u. 12
v. 15
w. 13
x. 17
y. 9
z. 17
aa. 8
bb. 4
cc. 5
dd. 8
ee. 4

5.
a. 1,2,4,5,23
b. 20
c. 14
d. 16
e. 26
f. 5
g. 9
h. 7
i. 5
j. 25
k. 18
l. 21
m. 11
n. 14
o. 22
p. 19
q. 23
r. 1
s. 3
t. 5
u. 7
v. 24
w. 8
x. 24
y. 1
z. 10
aa. 11
bb. 13
cc. 15
dd. 18
ee. 16
ff. 24
gg. 14
hh. 6
ii. 3
jj. 17
kk. 6
ll. 2
mm. 3
nn. 12

6.
a. Size
b. Design
c. Quality

7. a, b, c, f

8. Performance skills evaluated to the satisfaction of the instructor

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and use common specialty tools, power equipment, rules, scales, and test equipment. Competencies will be demonstrated by completing the assignment sheets, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to specialty tools and equipment with their correct definitions.
2. List typical power equipment.
3. Select true statements concerning general safety rules for using power equipment.
4. Label the parts of a hydraulic knockout set.
5. Complete statements concerning specific safety rules for using hydraulic knockout sets.
6. Label the parts of a hydraulic pipe bender.
7. Select true statements concerning specific safety rules for using hydraulic pipe benders.
8. Label the parts of an electrical polyvinyl chloride (PVC) heater.
9. Complete statements concerning specific safety rules for using electric polyvinyl chloride (PVC) heaters.

OBJECTIVE SHEET

10. Label the parts of a power drill.
11. Select true statements concerning specific safety rules for using power drills.
12. Label the parts of a power threader.
13. Complete statements concerning specific safety rules for using power threaders.
14. Identify typical rules and scales.
15. Identify typical test equipment.
16. Measure objects using a rule. (Assignment Sheet #1)
17. Determine lengths of lines using an architect's scale. (Assignment Sheet #2)
18. Demonstrate the ability to:
    a. Use a hydraulic knockout punch. (Job Sheet #1)
    b. Bend a 90-degree stub using a hydraulic pipe bender. (Job Sheet #2)
    c. Make offset and 90-degree bends using an electric PVC heater. (Job Sheet #3)
    d. Cut, ream, and thread rigid conduit with a power threader. (Job Sheet #4)
    e. Measure resistance using a VOM. (Job Sheet #5)
    f. Measure DC voltages using a VOM. (Job Sheet #6)
    g. Measure AC voltages using a VOM. (Job Sheet #7)
    h. Measure amperage using a clamp-on ammeter. (Job Sheet #8)
    i. Determine the current of a multiple-loop clamp-on ammeter. (Job Sheet #9)
    j. Check conductor insulation with a megger. (Job Sheet #10)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Invite a local electrical tool salesperson to show specialty tools and equipment to class.
2. Obtain tool catalogs from local suppliers.
3. Obtain test equipment catalogs from local suppliers.
4. Discuss the proper care and maintenance of specialty tools, power equipment, and test equipment with class.
5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *Using Electrical Test Equipment*. Rockville, MD: NUS Training Corporation, A Halliburton Company, 1980.

B. Siebert, Leo N. *Introduction to Industrial Electricity-Electronics*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1981.

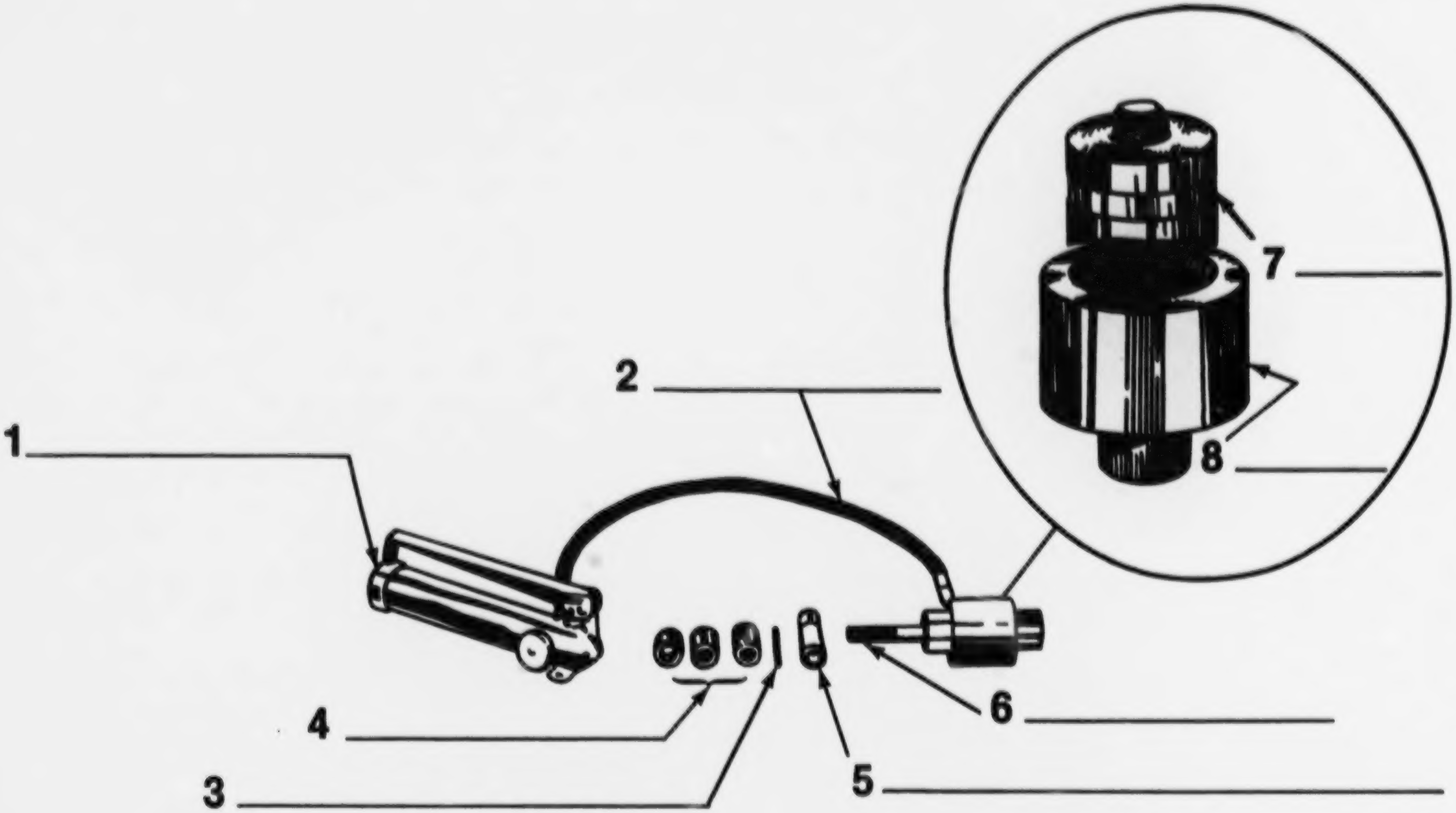
C. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

D. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

SUGGESTED SUPPLEMENTAL MATERIAL

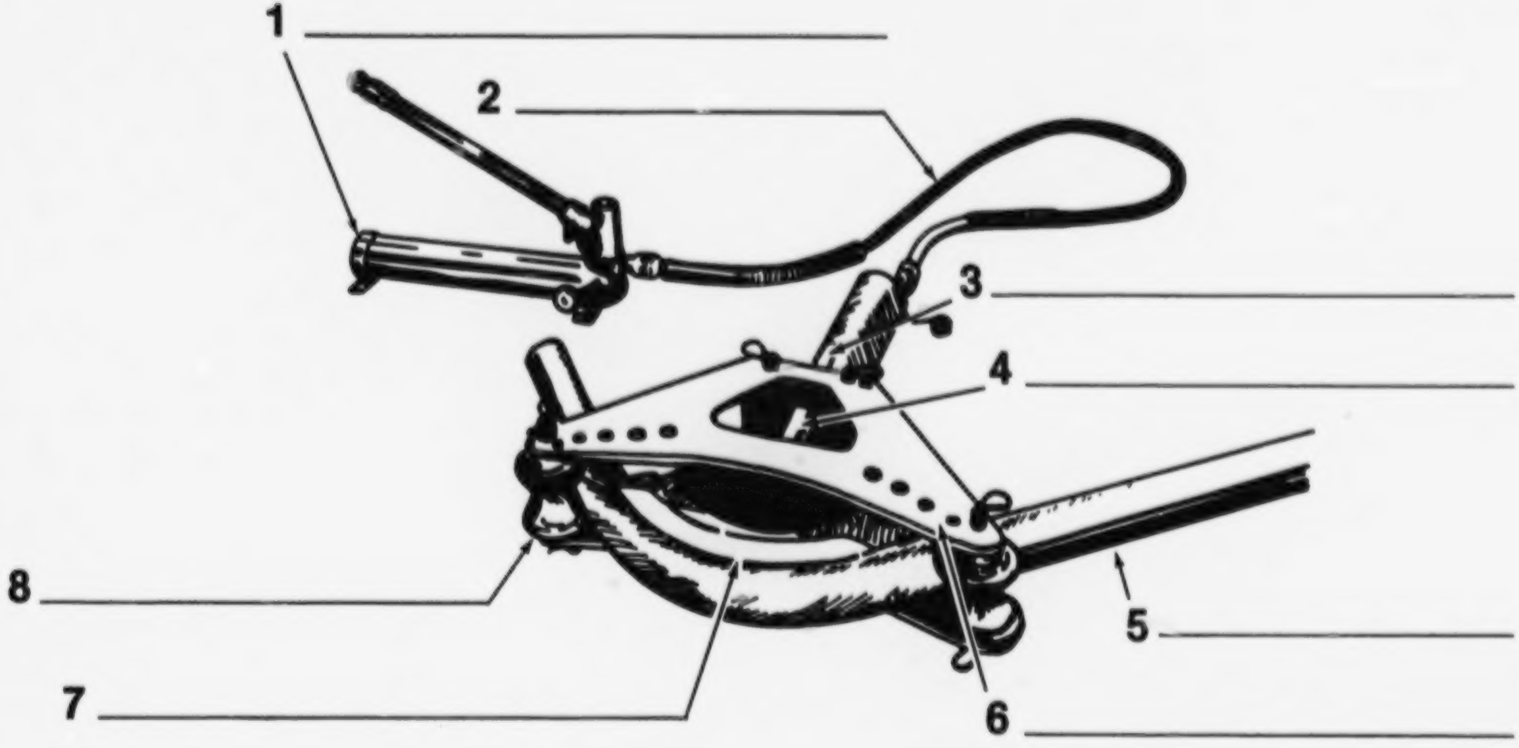
Publication — Klein Tool Catalog No. 129, Klein Tools Inc., 7200 McCormick Blvd., Chicago, IL 60645.

Hydraulic Knockout Set

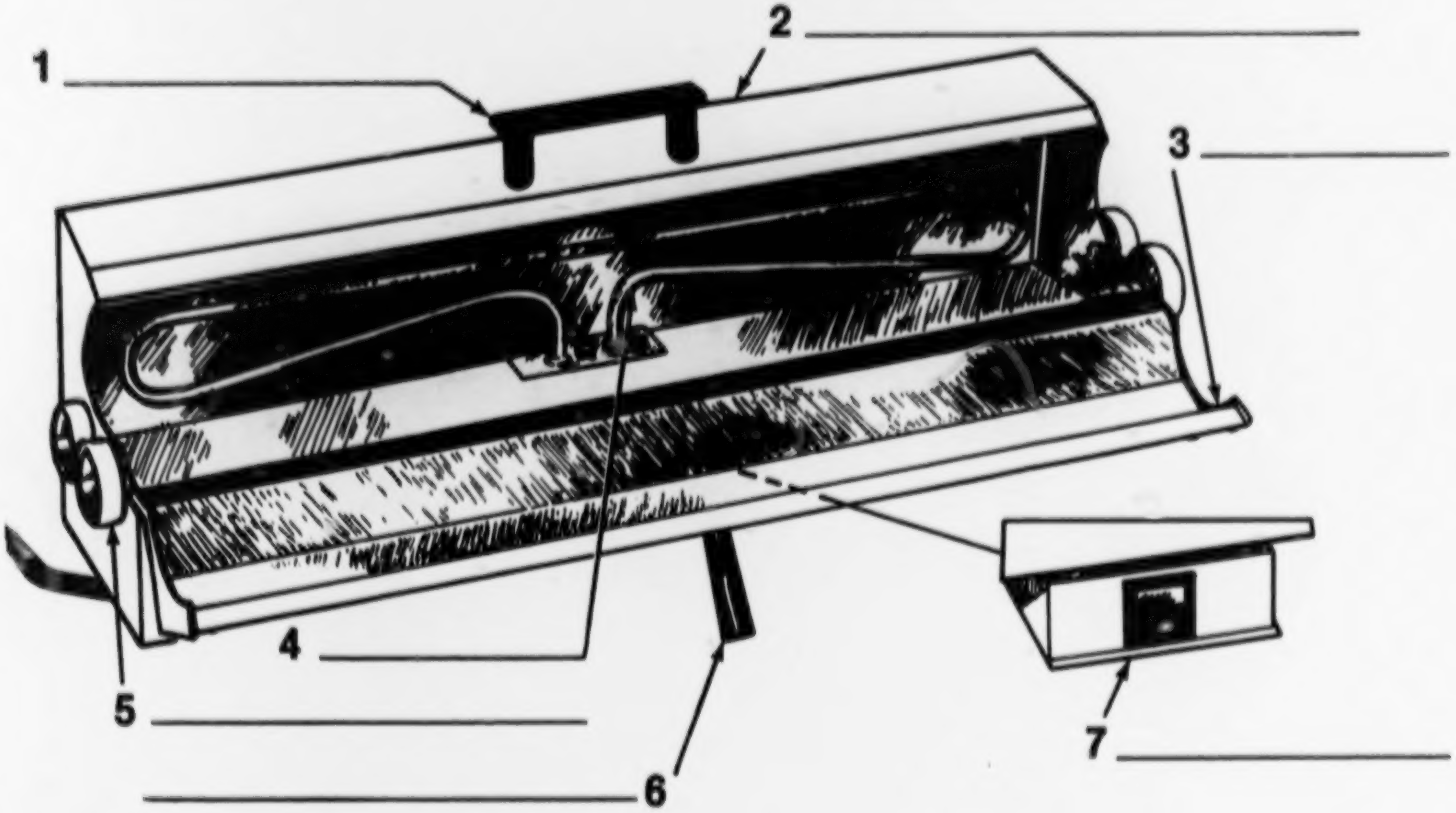


TM 1
Objective IV

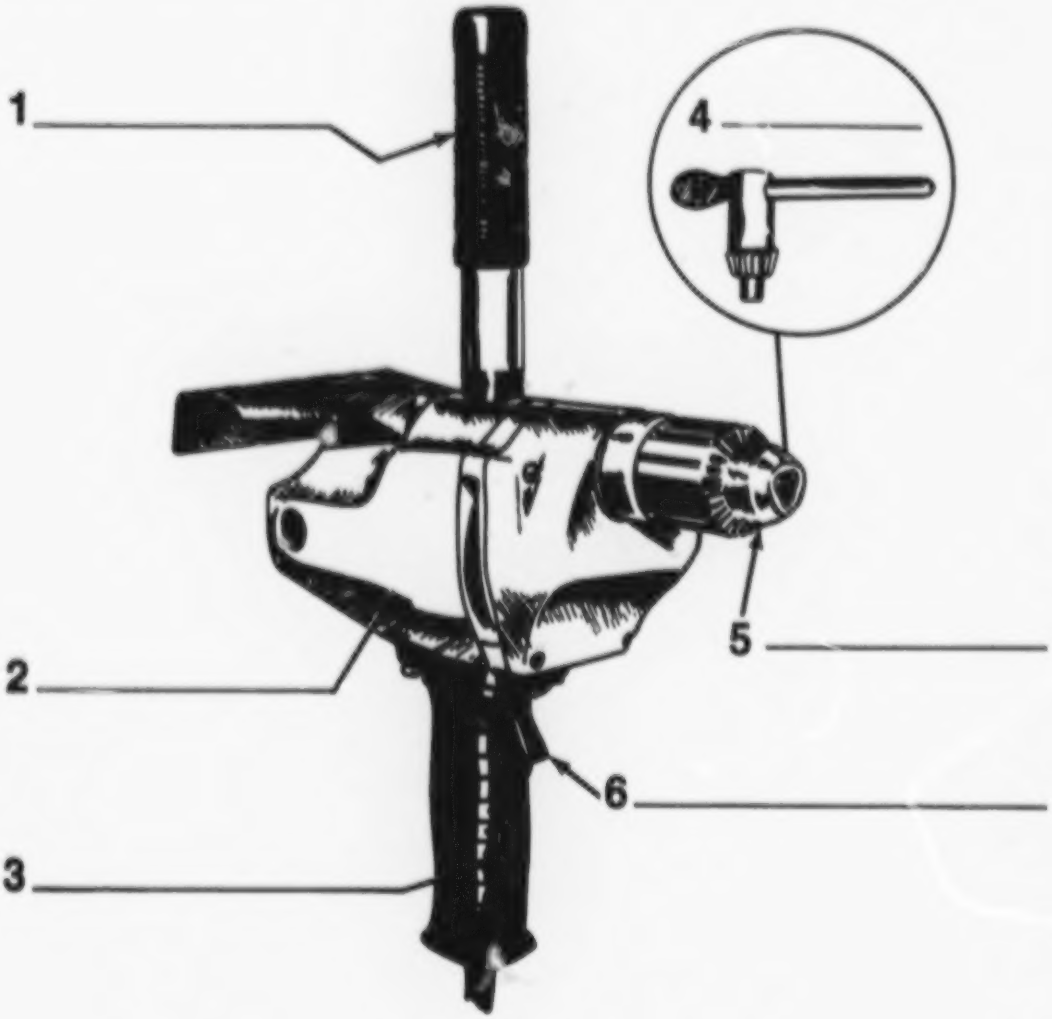
Hydraulic Pipe Bender



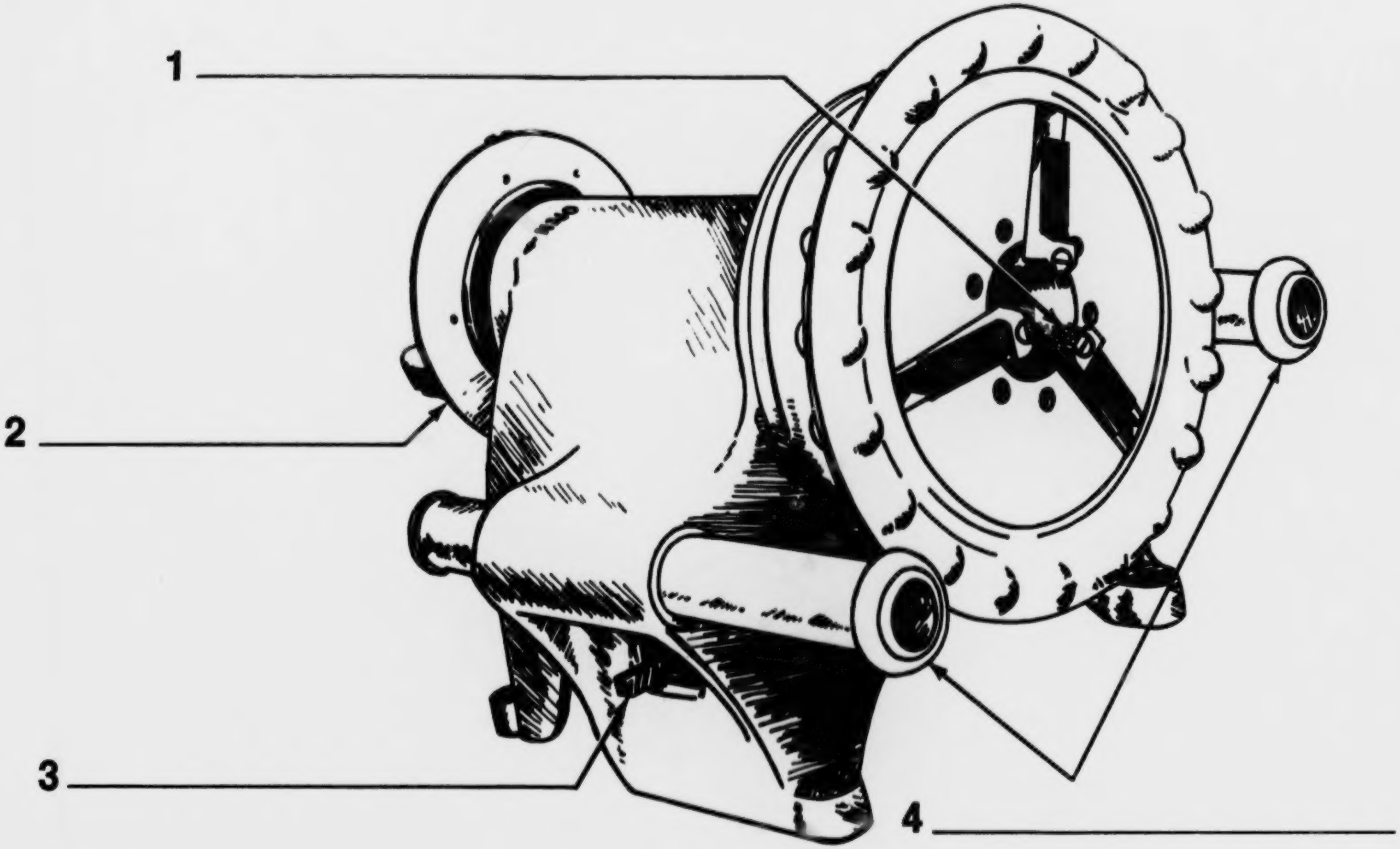
Electric PVC Heater



Power Drill



Power Threader

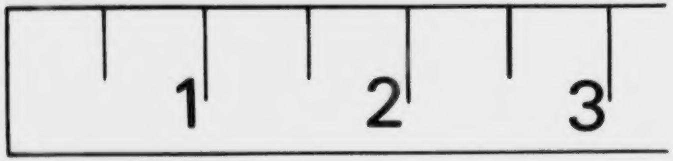


TM 5
Objective XII

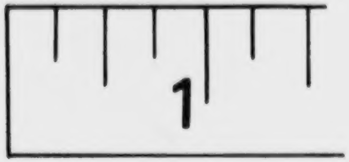
BW-207

Graduations on a Rule

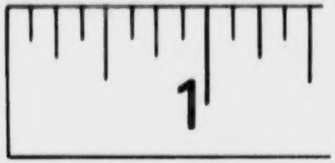
Halves



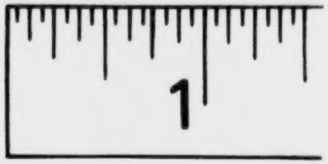
Quarters



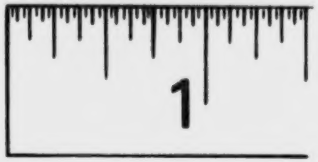
Eighths

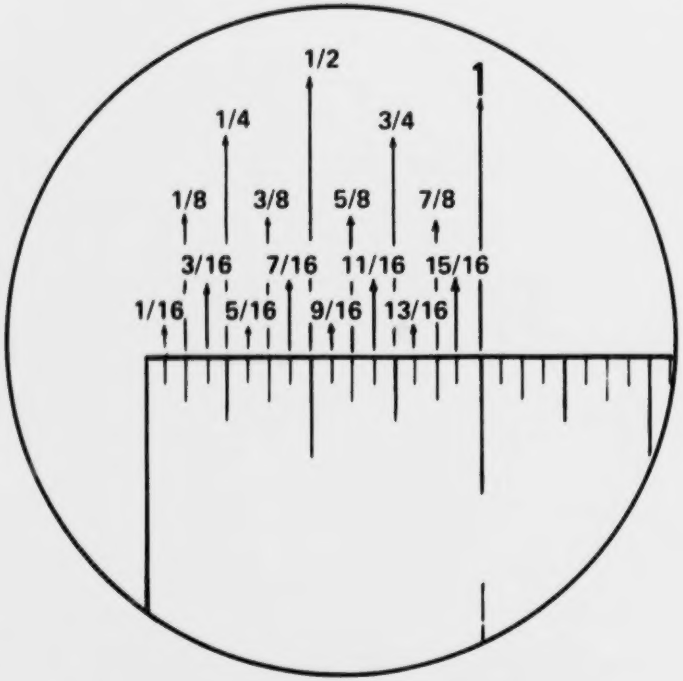


Sixteenths



Thirty-Seconds



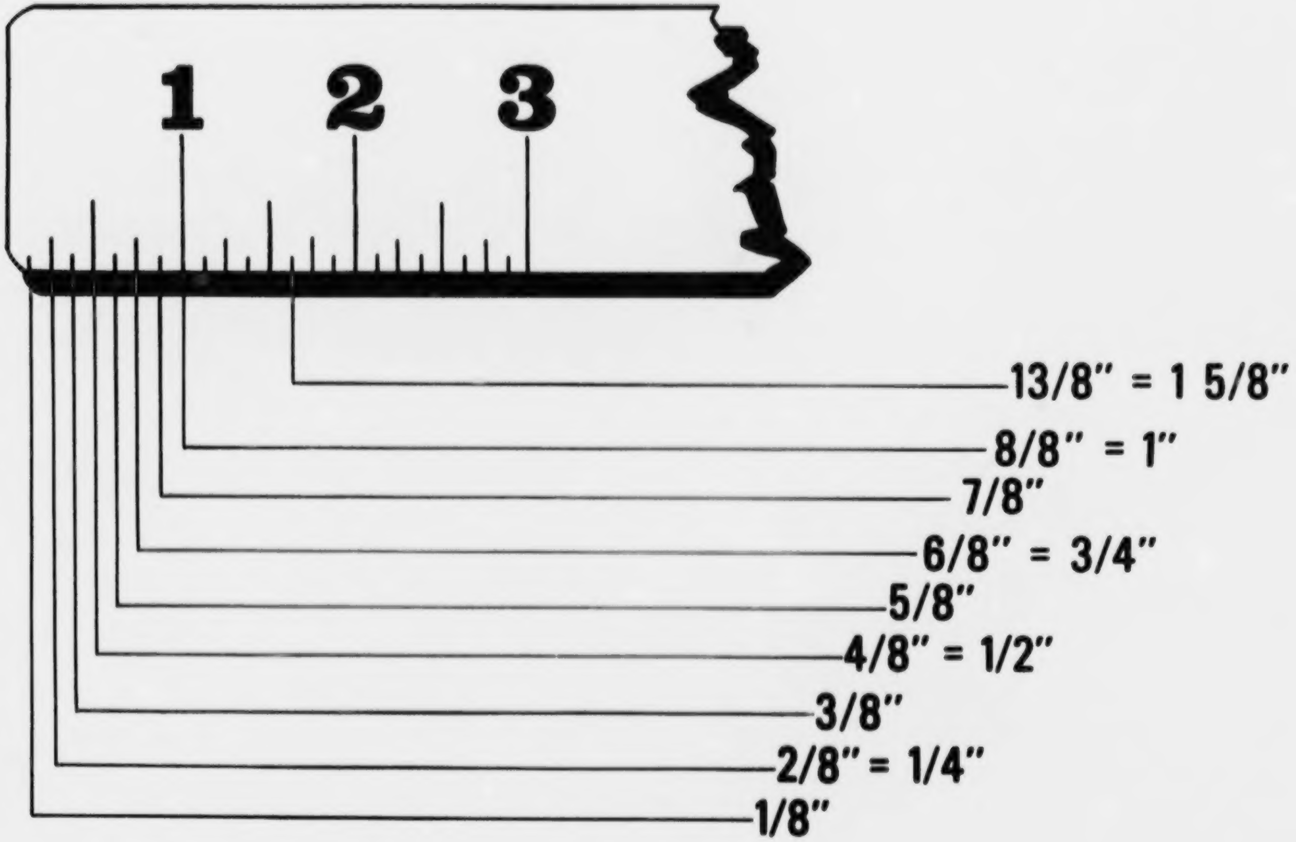

1/2
1
1/4
3/4
1/8
3/8
5/8
7/8
3/16
7/16
11/16
15/16
1/16
5/16
9/16
13/16

Graduations Applied to a Rule

TM 6
Objective XIV

BW-209

Reading the Eighths Rule



13/8" = 1 5/8"

8/8" = 1"

7/8"

6/8" = 3/4"

5/8"

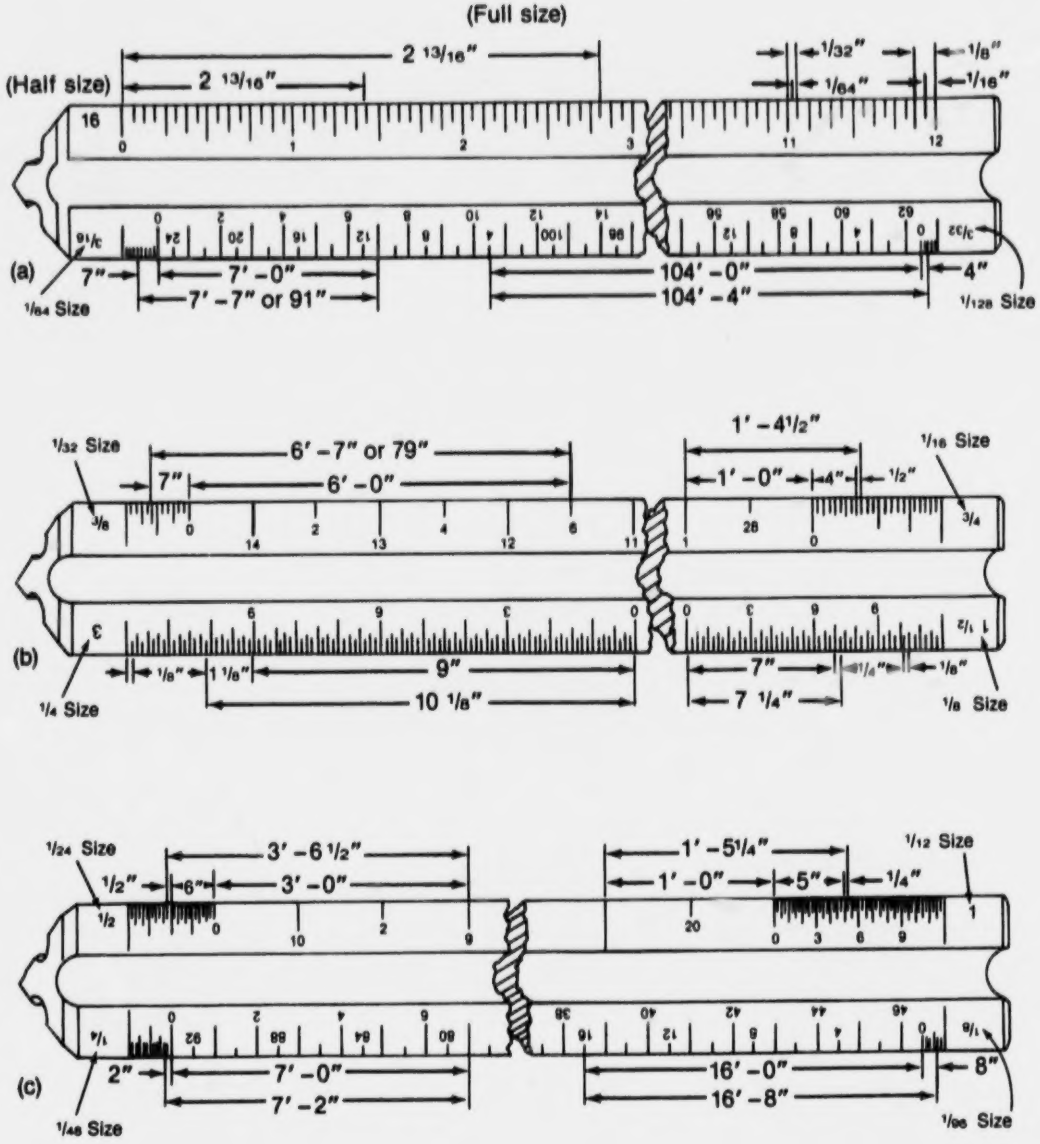
4/8" = 1/2"

3/8"

2/8" = 1/4"

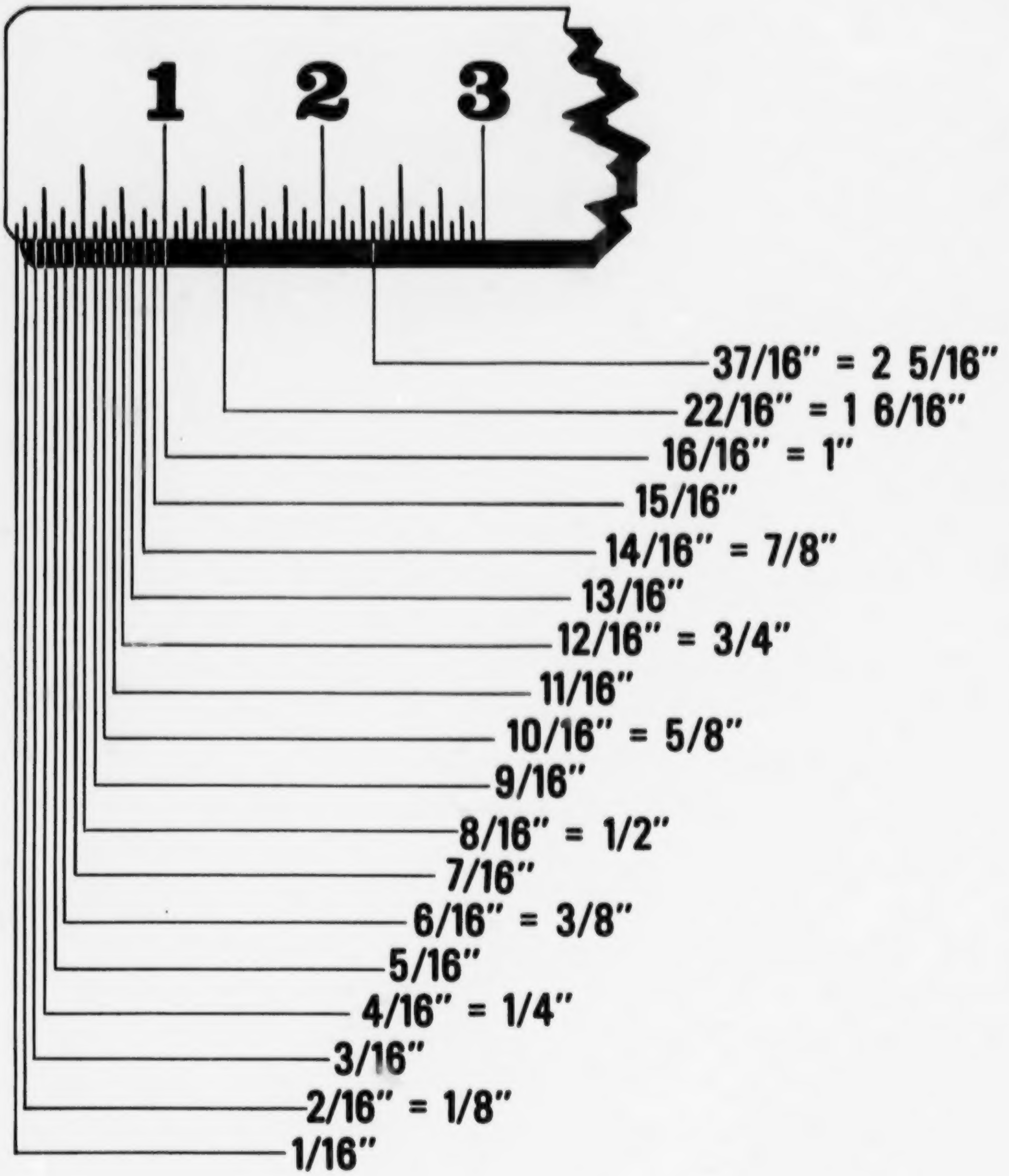
1/8"

Architect's Scale

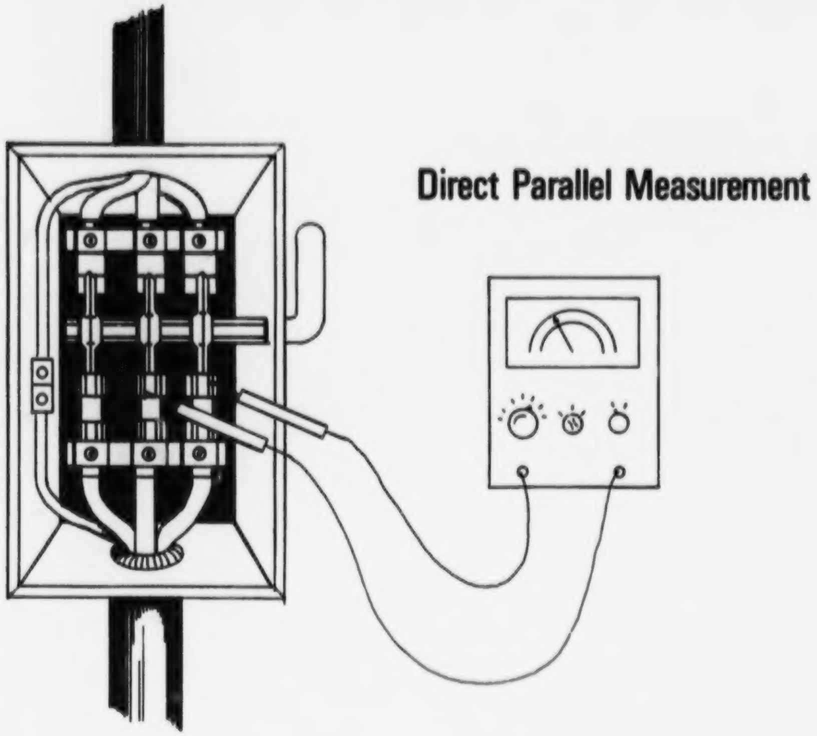

(Full size)
(Half size)
2 13/16"
2 13/16"
1/32"
1/64"
1/8"
1/16"
(a)
1/64 Size
7"
7'-0"
7'-7" or 91"
104'-0"
104'-4"
4"
1/128 Size
1/32 Size
6'-7" or 79"
7"
6'-0"
1'-4 1/2"
1'-0"
4"
1/2"
1/16 Size
(b)
1/4 Size
1/8"
1 1/8"
9"
10 1/8"
7"
1/4"
1/8"
7 1/4"
1/8 Size
1/24 Size
1/2"
6"
3'-6 1/2"
3'-0"
1'-5 1/4"
1'-0"
5"
1/4"
1/12 Size
(c)
1/48 Size
2"
7'-0"
7'-2"
16'-0"
16'-8"
8"
1/96 Size

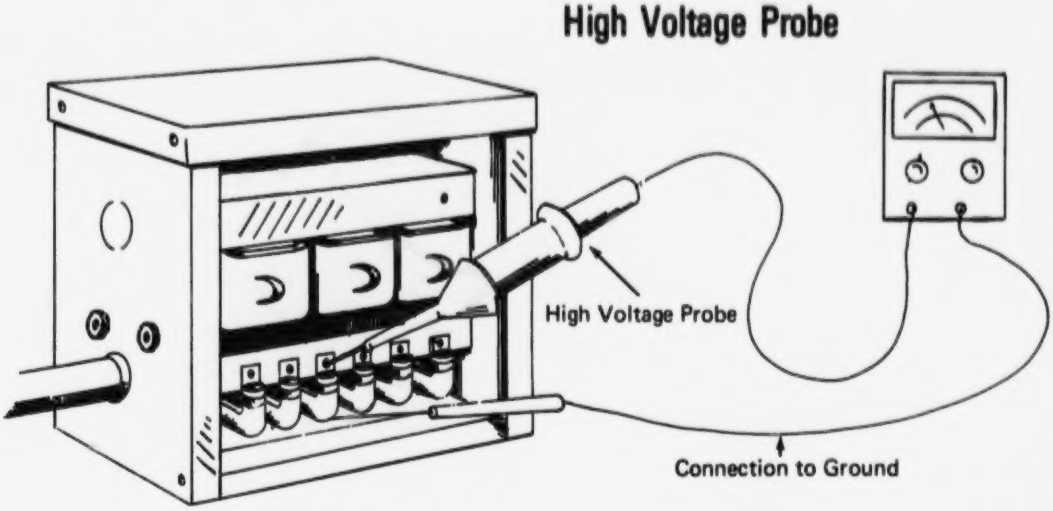
This is how the Architect's Scale should look.

Reading the Sixteenths Rule

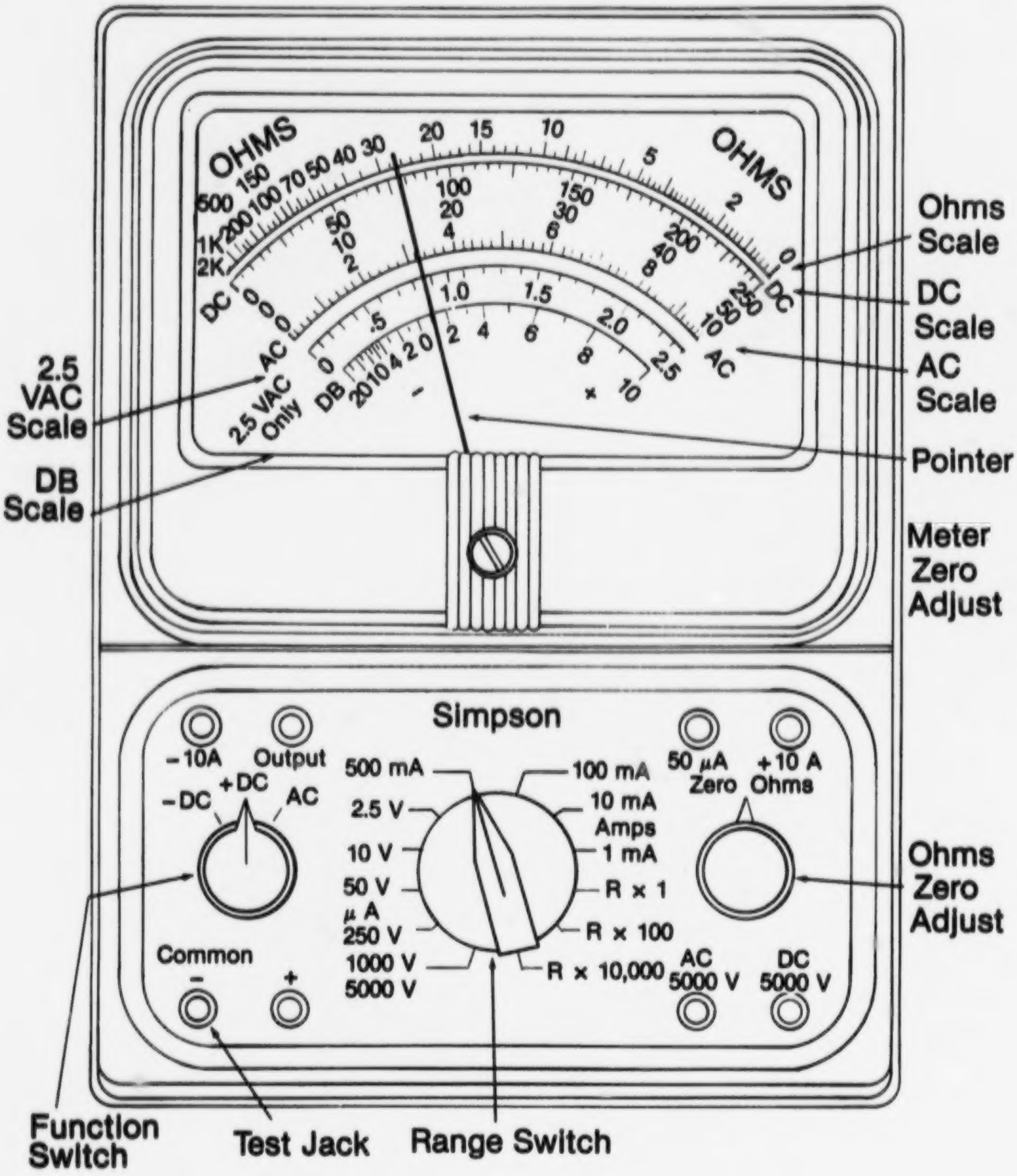

1
2
3
37/16" = 2 5/16"
22/16" = 1 6/16"
16/16" = 1"
15/16"
14/16" = 7/8"
13/16"
12/16" = 3/4"
11/16"
10/16" = 5/8"
9/16"
8/16" = 1/2"
7/16"
6/16" = 3/8"
5/16"
4/16" = 1/4"
3/16"
2/16" = 1/8"
1/16"

Voltage Measurement Techniques

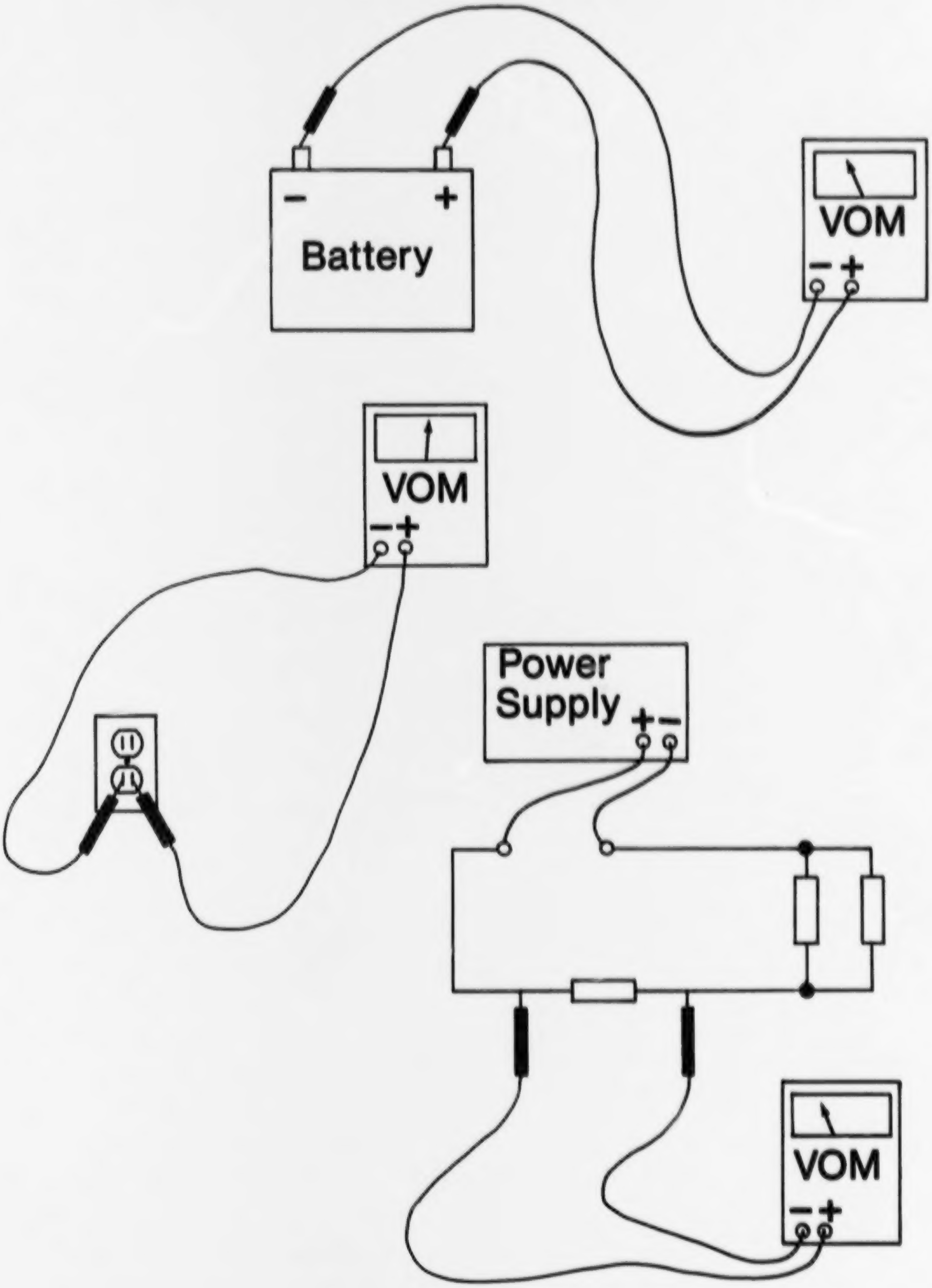

Direct Parallel Measurement


High Voltage Probe
High Voltage Probe
Connection to Ground

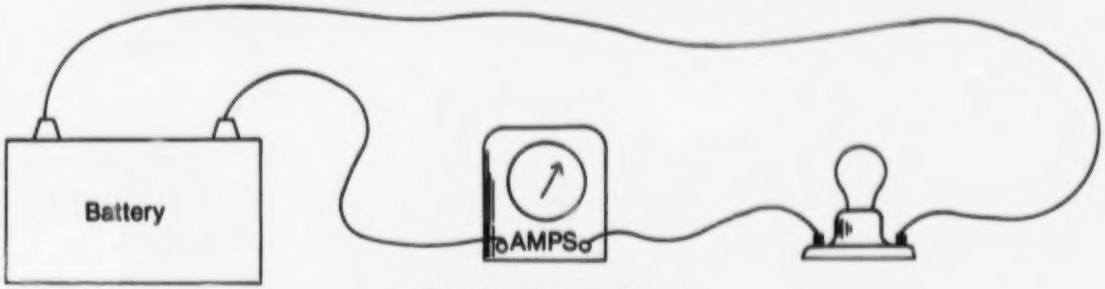
Permanent Magnet Moving Coil Multimeter


OHMS
OHMS
500 150
1K 200 100 70 50 40 30
2K
20 15 10 5 2 0
100
20
4
150
30
6
200
40
8
250
50
10
DC
0 0 0
50 10 2
AC
.5 1.0 1.5 2.0 2.5
0 2 4 6 8 10
DB 20 10 4 2 0
-
+
2.5 VAC Only
Ohms Scale
DC Scale
AC Scale
2.5 VAC Scale
DB Scale
Pointer
Meter Zero Adjust
Simpson
-10A
Output
-DC
+DC
AC
500 mA
2.5 V
10 V
50 V
μA 250 V
1000 V 5000 V
100 mA
10 mA Amps
1 mA
R × 1
R × 100
R × 10,000
50 μA Zero
+10 A Ohms
Ohms Zero Adjust
Common
-
+
AC 5000 V
DC 5000 V
Function Switch
Test Jack
Range Switch

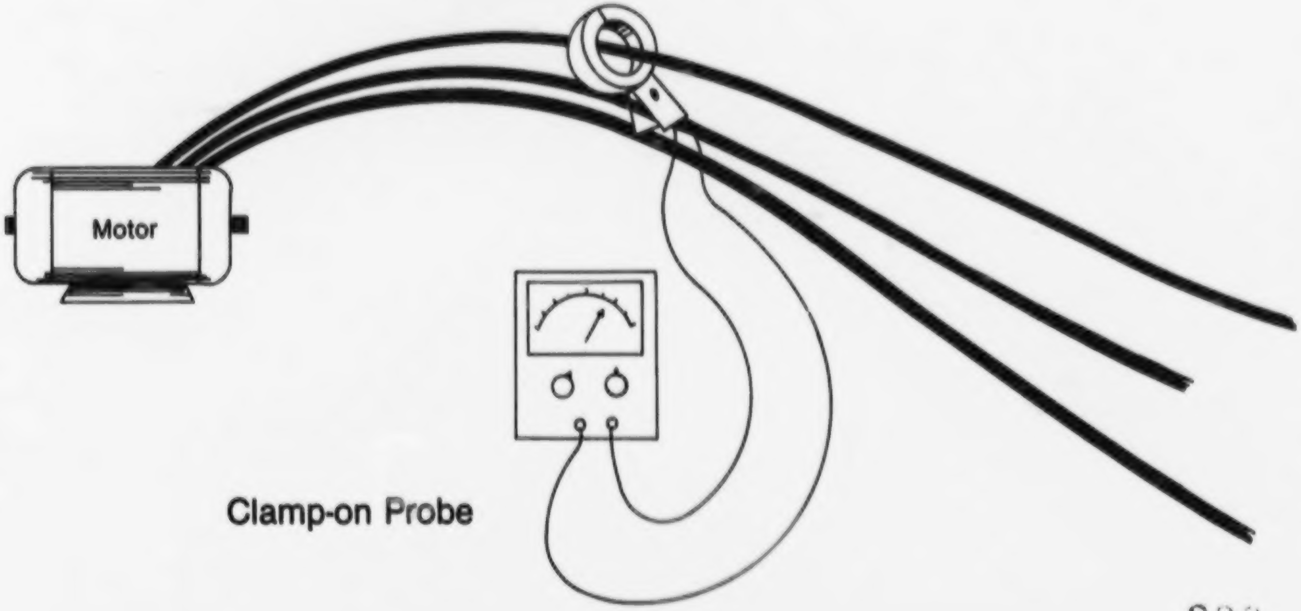
Correct Voltage Measurements


–
+
Battery
VOM
– +
VOM
– +
Power
Supply
+ –
VOM
– +

Amperage Measurement Techniques


Battery
AMPS

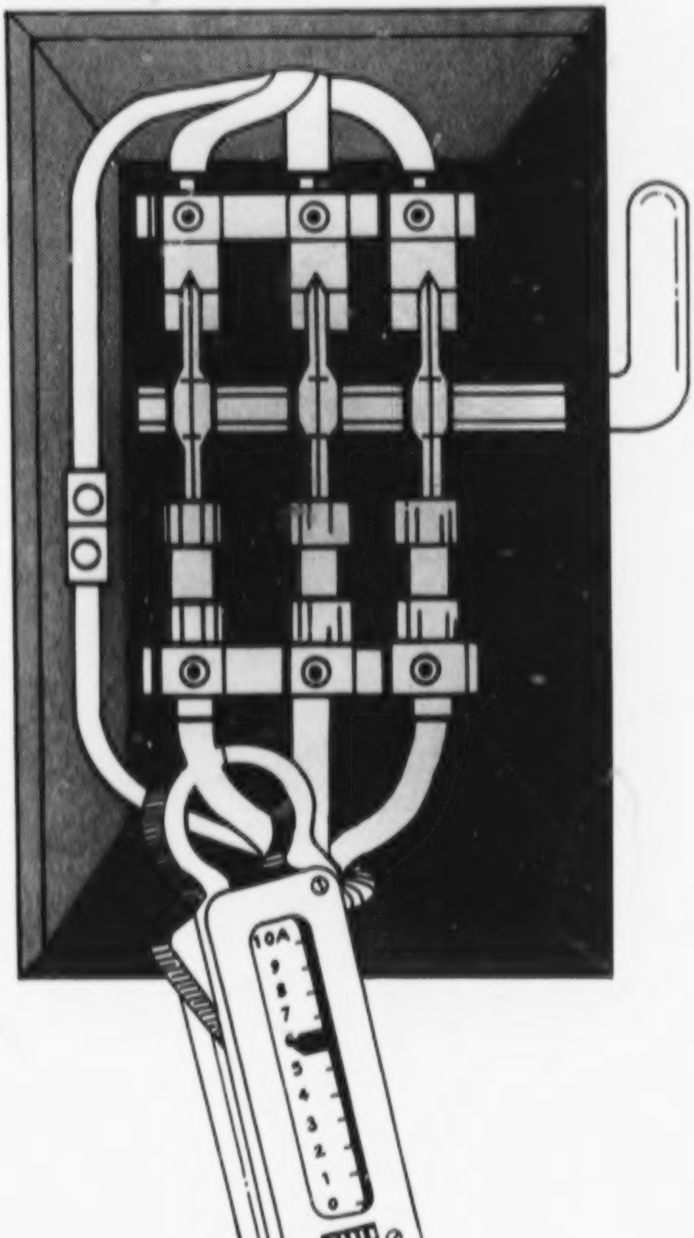
Series Ammeter



Clamp-on Probe

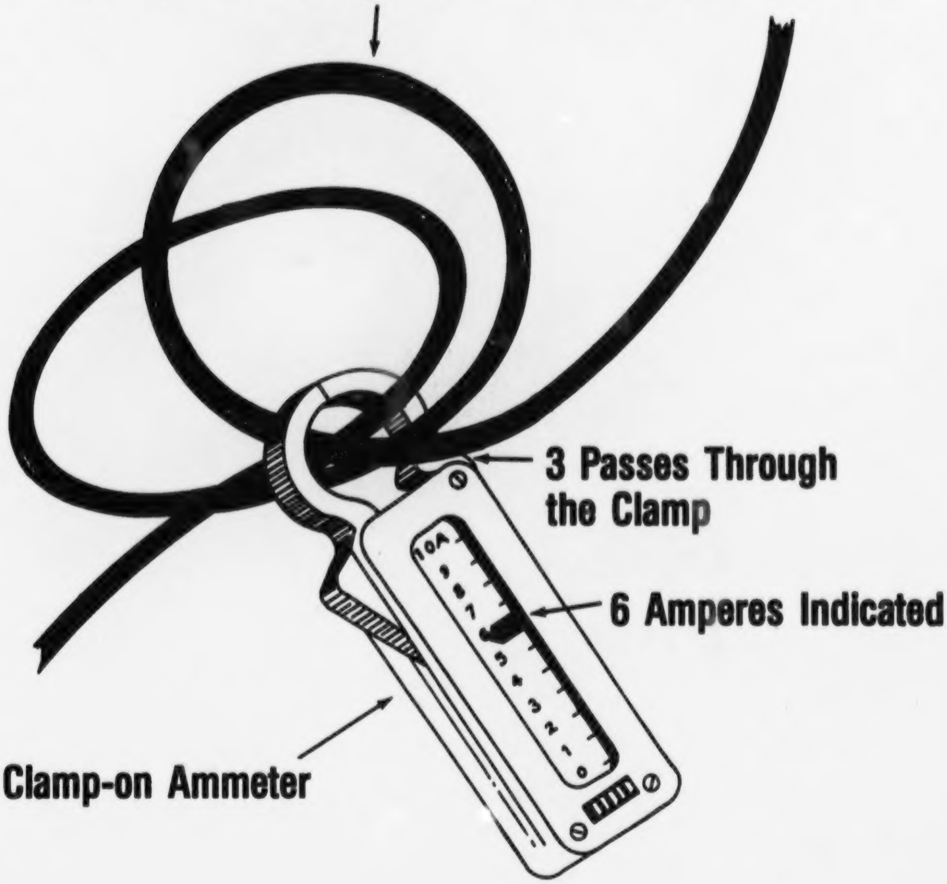
Clamp-on Ammeter

Measuring Current In A
Safety Switch Using Clamp-on Ammeter


10A
9
8
7
6
5
4
3
2
1
0

Determining Current of a Multiple Loop Using a Clamp-on Ammeter

2 Amperes Through the Insulated Cable



3 Passes Through the Clamp

6 Amperes Indicated

Clamp-on Ammeter

(NOTE: The loops should be wrapped tightly together at the point of measurement with electrical tape.)

TM 15
Objective XV

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

INFORMATION SHEET

I. **Terms and definitions**

A. Accuracy — How near the instrument reading is to the actual value

B. Amperage — Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

C. Bender — Tool used to make various angles or bends in conduit

D. Calibration — Technique of testing and adjusting an instrument by referencing it to another instrument or device of known accuracy and precision

E. Chuck — Portion of drill that holds the bit

F. Cross handle — Handle set across a power tool to prevent the tool from turning

G. Cutter — Hardened steel device used to cut holes in metal boxes

H. Die — Component that backs up cutter on opposite side of metal box

I. Error — How far the measurement is from the actual value

J. Ground — Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

K. Hydraulic — Using pressurized fluid to accomplish work

L. Hydraulic oil — Specially formulated oil for hydraulic pumps

(NOTE: No oil or fluid should ever be substituted for hydraulic oil.)

M. Knockout punch — Device used to make openings for conduit in metal enclosures

N. Multimeter — Instrument capable of measuring a "multiple" of values

EXAMPLES: Amperage, voltage, and resistance with several measurement ranges

O. Parallax correction — Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

P. Pinch point — Any opening that may close and bind a finger or hand

Q. Polyvinyl chloride (PVC) — Plastic pipe

INFORMATION SHEET

R. Precision — Instrument consistency

EXAMPLE: A "precision meter" might not be accurate. It may measure 1 volt at 1.20 volts, but each time the reading will be precisely 1.20, not 1.21 or 1.19. A calibration adjustment could correct the meter reading to 1.00 at 1 volt and would then precisely repeat a 1.00 reading.

S. Ram — Device used to transfer hydraulic pressure to a mechanical device

T. Resistance — Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

U. Resolution — How well an instrument will indicate a small change in the measured value

EXAMPLE: A precise, accurate, and sensitive meter may respond by moving the meter hand 1/16" for a small change in measured amperage. If the scale is marked only one division per inch, the meter would still lack "resolution" since the operation could not determine what amount of current change this represents.

V. Voltage — Electromotive force (emf); force that drives electricity through conductors; must be measured across, between, or be referenced to a second point

EXAMPLE: Ground

II. **Typical power equipment**

A. Hydraulic knockout

B. Hydraulic bender

C. Electric PVC heater

D. Power drill

E. Power threader

III. **General safety rules for using power equipment**

A. Always follow manufacturer's operating instructions.

B. Never place hands in a pinch point.

C. Use eye protection.

INFORMATION SHEET

D. Wear gloves when working with hot equipment or materials.

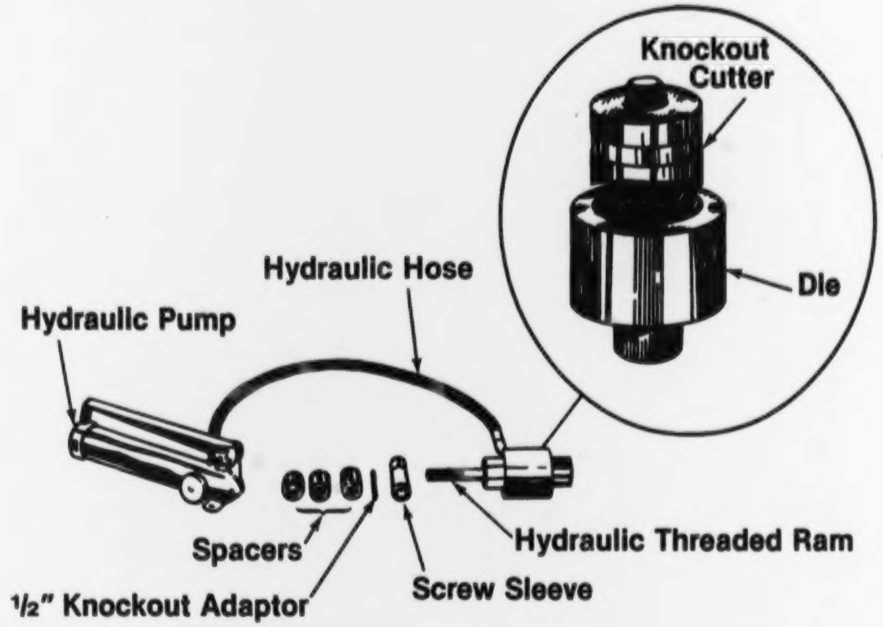
E. Always secure loose clothing such as shirt sleeves and shirttails.

F. Never exceed rated capacity of equipment.

G. Never leave running equipment unattended.

H. Never remove protective guards from equipment.

IV. **Parts of a hydraulic knockout set**


Knockout Cutter
Die
Hydraulic Hose
Hydraulic Pump
Spacers
½" Knockout Adaptor
Screw Sleeve
Hydraulic Threaded Ram

V. **Specific safety rules for using hydraulic knockout sets**

A. Never substitute brake fluid for hydraulic oil.

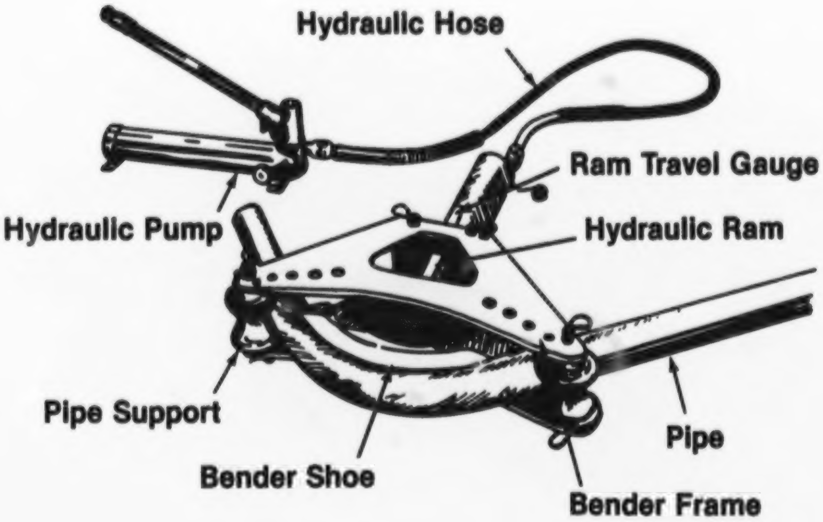
B. Never disconnect hose when it is under pressure.

C. Do not use near live electrical parts.

D. Never force pump handle.

INFORMATION SHEET

VI. **Parts of a hydraulic pipe bender**


Hydraulic Hose
Ram Travel Gauge
Hydraulic Pump
Hydraulic Ram
Pipe Support
Pipe
Bender Shoe
Bender Frame

VII. **Specific safety rules for using hydraulic pipe benders**

A. Never substitute brake fluid for hydraulic oil.

B. Never disconnect hose when it is under pressure.

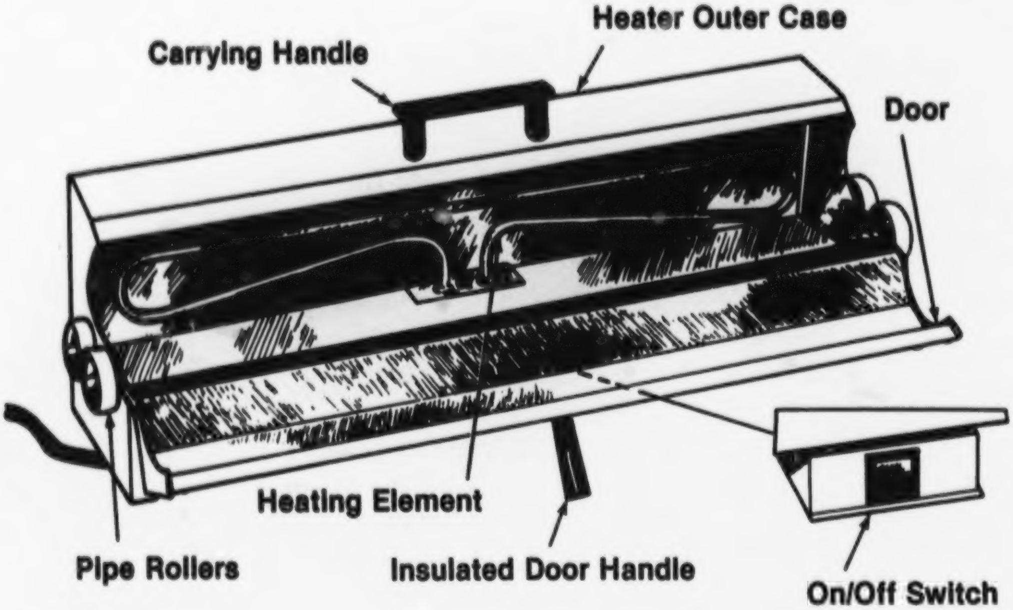
C. Never place hands near ram or shoe while bending.

D. Always use proper side of conduit shoe and support.

E. Be sure that floor area is clear for pipe movement.

INFORMATION SHEET

VIII. **Parts of an electric polyvinyl chloride (PVC) heater**


Heater Outer Case
Carrying Handle
Door
Heating Element
Pipe Rollers
Insulated Door Handle
On/Off Switch

IX. **Specific safety rules for using electric polyvinyl chloride (PVC) heaters**

A. Never use in wet locations.

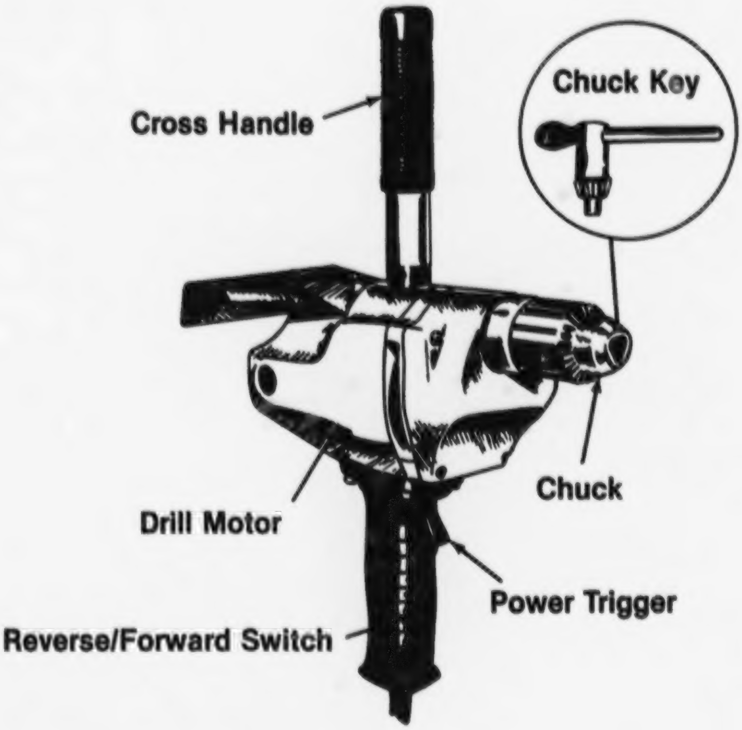
B. Always wear gloves when handling hot water or pipe.

C. Use only with PVC conduit.

D. Always turn bender off when not in use.

INFORMATION SHEET

X. Parts of a power drill


Cross Handle
Chuck Key
Chuck
Drill Motor
Power Trigger
Reverse/Forward Switch

XI. Specific safety rules for using power drills

A. Always wear eye protection.

B. Check area to be drilled for hidden wires or pipes.

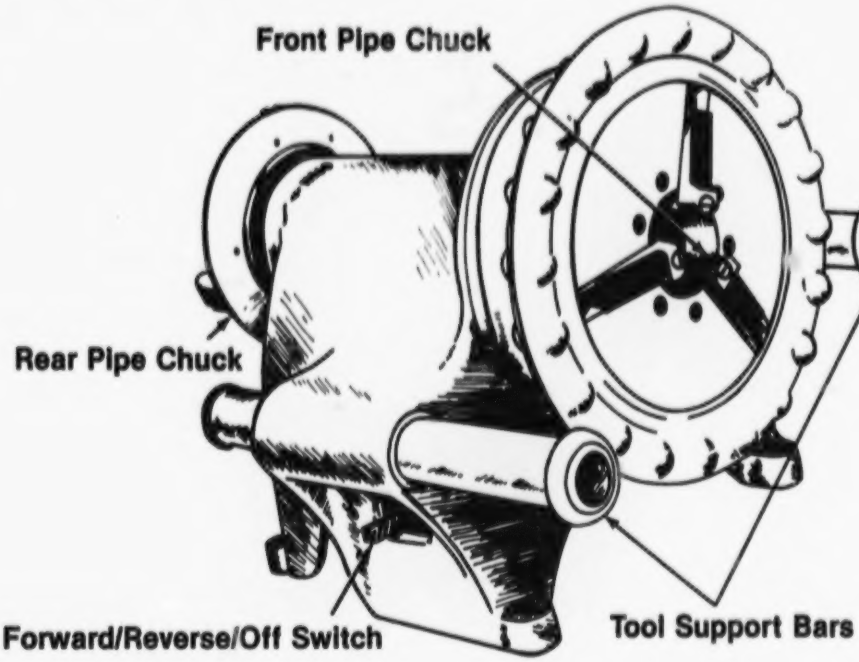
C. Hold drill securely with both hands.

D. Never drill while off balance.

E. Place small objects to be drilled in a vise.

INFORMATION SHEET

XII. Parts of a power threader


Front Pipe Chuck
Rear Pipe Chuck
Forward/Reverse/Off Switch
Tool Support Bars

XIII. Specific safety rules for using power threaders

A. Always wear eye protection.

B. Always wear tight-fitting clothing.

C. Use gloves when handling pipe.

D. Never place hands near turning pipe.

E. Let threader come to a complete stop before removing pipe or reversing direction.

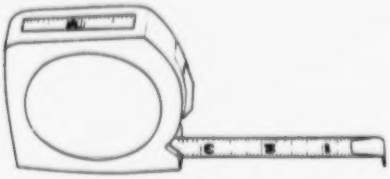
F. Always use a brush to clear thread cuttings.

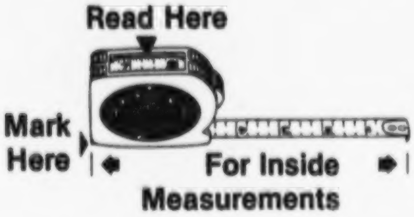
(NOTE: Never use your hands to clear thread cuttings.)

INFORMATION SHEET

XIV. Typical rules and scales

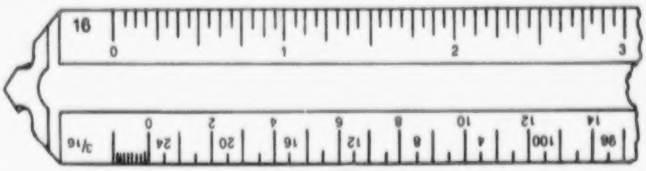
A. Sixteen foot tape




Read Here
Mark Here
For Inside Measurements

(NOTE: Tapes are normally graduated into 1/16" increments.)

B. Architect's scale


16
0
1
2
3
3/16
24
20
16
12
8
4
100
96

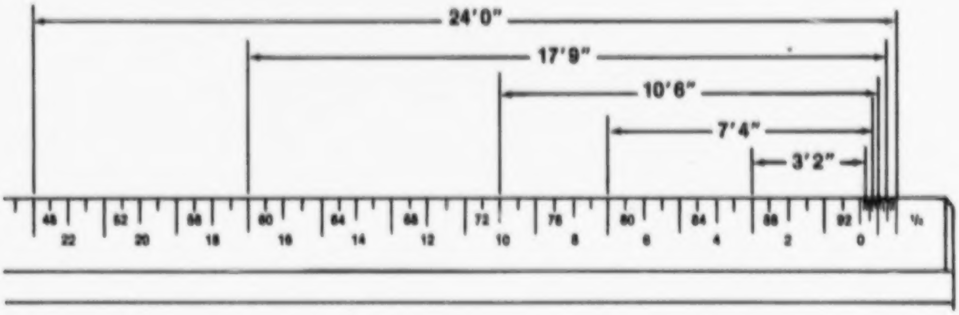
Scale ratios found on architect's scale

12" = 1'-0" — Full size
6" = 1'-0" — Half size
3" = 1'-0" — 1/4 size
1 1/2" = 1'-0" — 1/8 size
1" = 1'-0" — 1/12 size
3/4" = 1'-0" — 1/16 size

1/2" = 1'-0" — 1/24 size
3/8" = 1'-0" — 1/32 size
1/4" = 1'-0" — 1/48 size
3/16" = 1'-0" — 1/64 size
1/8" = 1'-0" — 1/96 size
3/32" = 1'-0" — 1/128 size

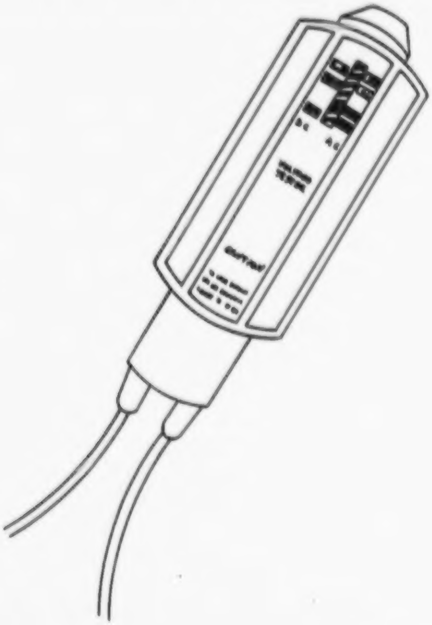
INFORMATION SHEET

(NOTE: An architect's scale is used to measure distances on prints. A typical blueprint may be drawn ¼" = 1'. In that case, the scale may be laid down by the line to be measured, using the ¼" scale. If the line is 7 units long, that will be equal to 7'.)


24'0"
17'9"
10'6"
7'4"
3'2"
48
52
56
60
64
68
72
76
80
84
88
92
¼
22
20
18
16
14
12
10
8
6
4
2
0

XV. **Typical test equipment**

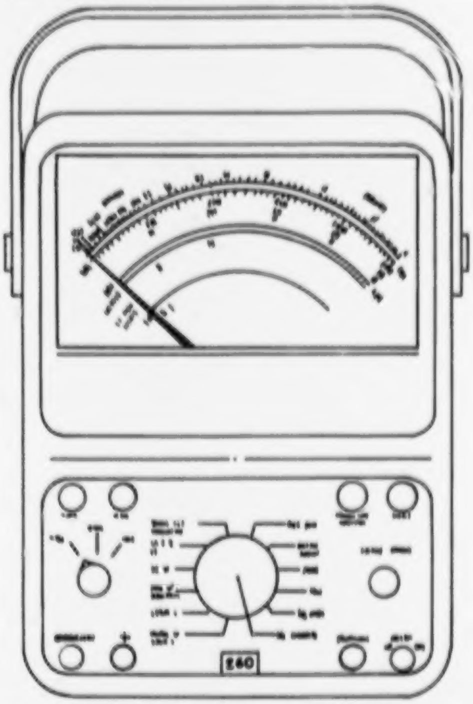
A. Voltage tester — A simple piece of electrical test equipment used to determine the presence of voltage at a power source. If a voltage is present, the tester will indicate an APPROXIMATE value.



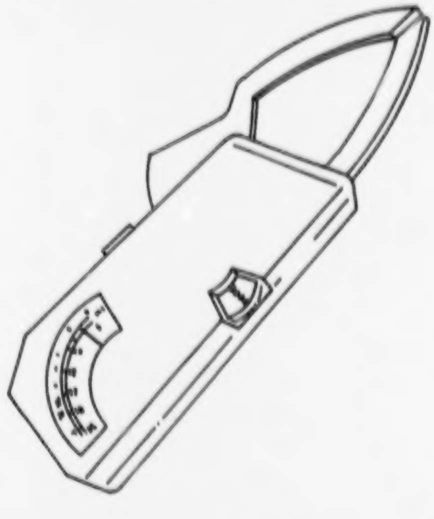
INFORMATION SHEET

B. Permanent magnet moving coil multimeter (VOM) — A VOM is an instrument that is designed to indicate specific quantities of voltage, resistance, or amperage

(NOTE: VOM indicates volt-ohm-meter.)

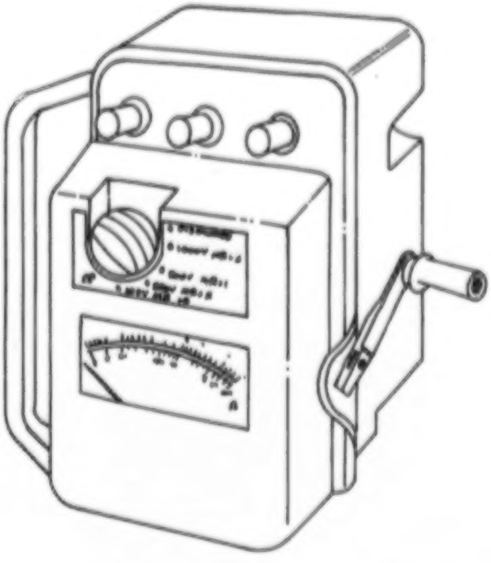


C. Clamp-on ammeter — Designed to clamp around an energized conductor and indicates the value of the current flowing through the conductor; it can measure higher current values than a VOM can.



INFORMATION SHEET

D. Megometer (Megger) — Able to measure resistance of several million ohms. The instrument is typically used to test conductor insulation.



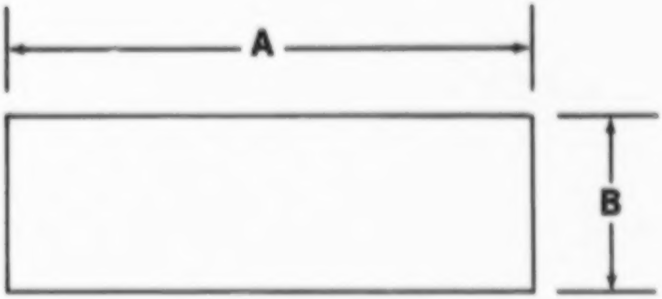
SPECIALTY TOOLS AND EQUIPMENT
UNIT V

ASSIGNMENT SHEET #1 — MEASURE OBJECTS USING A RULE

NAME ______________________________ SCORE ____________

Directions: Using a rule with one-sixteenth inch graduations, measure the following objects.

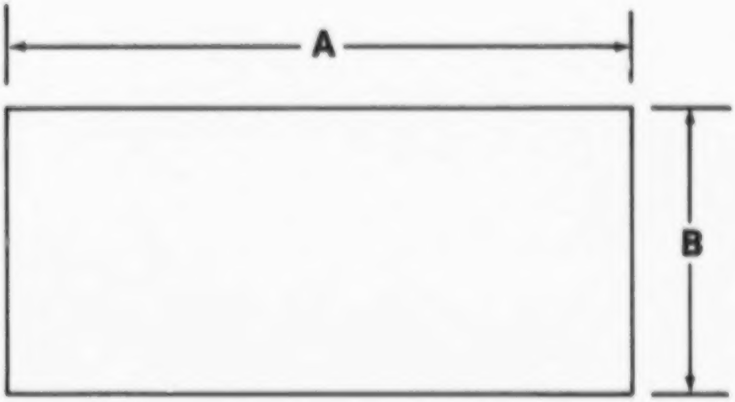
1.



a. Length ____________

b. Height ____________

2.

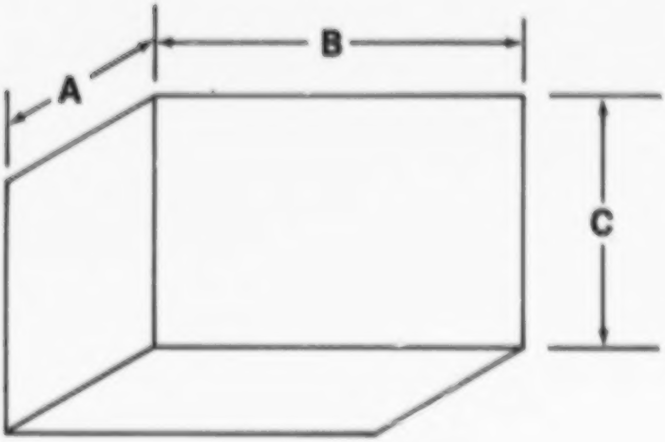


a. Length ____________

b. Height ____________

ASSIGNMENT SHEET #1

3.

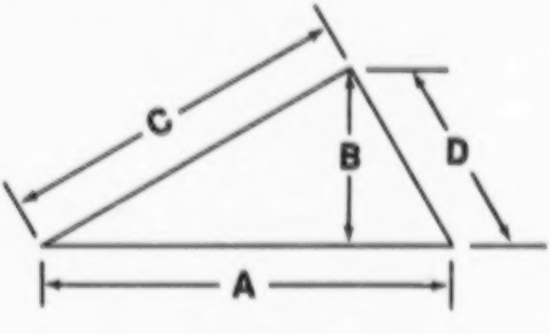


a. Width ____________

b. Length ____________

c. Height ____________

4.



a. Base ____________

b. Height ____________

c. Slope #1 ____________

d. Slope #2 ____________

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

ASSIGNMENT SHEET #2 — DETERMINE LENGTHS OF LINES USING AN ARCHITECT'S SCALE

NAME ________________________________ SCORE ______________

Directions: Measure the lines A through J to the scale heading each column in the table. Print the scale readings above the lines in the table.

(NOTE: Readings must be accurate or they will be considered wrong.)

$^{3}/_{32} = 1'$ A

$^{1}/_{8} = 1'$ B

$^{1}/_{4} = 1'$ C

$^{3}/_{16} = 1'$ D

$^{1}/_{2} = 1'$ E

$1'' = 1'$ F

$1\,^{1}/_{2} = 1'$ G

$^{3}/_{4} = 1'$ H

$^{1}/_{4} = 1'$ I

$^{1}/_{8} = 1'$ J

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. A. 3"
   B. 1"

2. A. 3 9/16"
   B. 1 3/8"

3. A. 1"
   B. 2 1/8"
   C. 1 7/16"

4. A. 2 3/8"
   B. 1"
   C. 2 1/16"
   D. 1 3/16"

Assignment Sheet #2

A. 65'
B. 38'6"
C. 15'11"
D. 23'6"
E. 10'10 1/2"
F. 3'5"
G. 1'6 1/2"
H. 1'9 1/2"
I. 2'11"
J. 2'

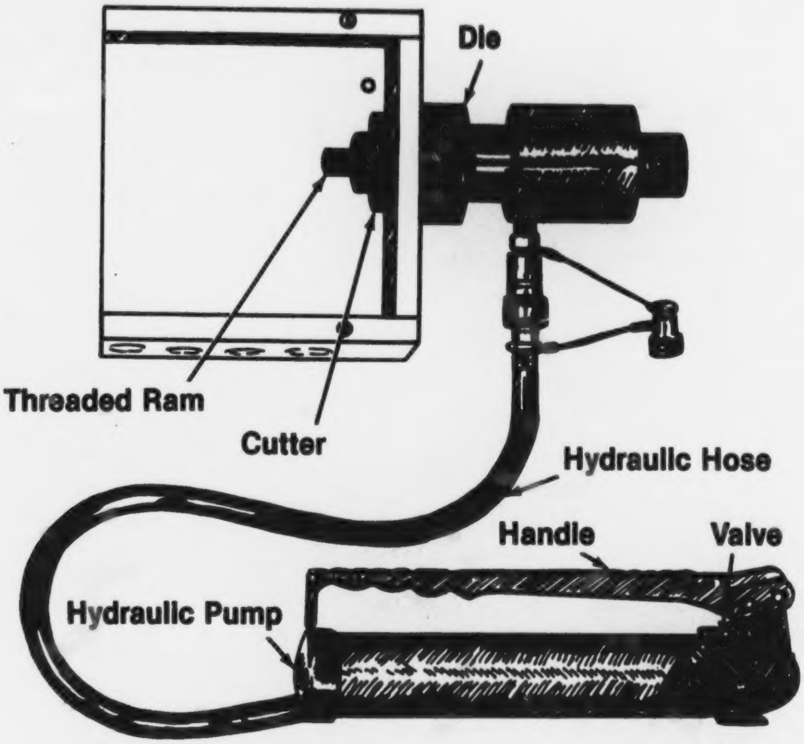
SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #1 — USE A HYDRAULIC KNOCKOUT PUNCH

A. Equipment and materials needed

1. Hydraulic knockout punch with hand pump (Figure 1)

FIGURE 1


Die
Threaded Ram
Cutter
Hydraulic Hose
Handle
Valve
Hydraulic Pump

2. Instructions for knockout punch

3. Drill motor

4. Metal drill bit

   (NOTE: The drill bit must be large enough to accept the knockout punch bolt.)

5. Metal to be punched

   (NOTE: Most punches are rated up to 10-gauge metal.)

JOB SHEET #1

6. Vise

   (NOTE: A vise is needed if metal to be cut is not fastened to a wall, or if metal is too small to hold.)

7. Eye protection

8. Heavy-duty extension cord

9. Center punch

10. Gloves

B. Procedure

1. Read instructions for hydraulic knockout set.

2. Assemble hydraulic knockout set, referring to instructions and to Figure 1.

3. Put on eye protection.

4. Fasten metal to be punched in vise if necessary.

5. Put on gloves.

6. Use center punch to make an indentation in the center of the space to be knocked out.

7. Place drill bit on indentation made with center punch, and drill a hole slightly larger than the knockout punch bolt.

   (CAUTION: Hold the drill firmly while drilling. A loose grip could cause an accident. Remember that the drill will be hot. Use caution until it cools.)

8. Separate knockout punch cutter from die and threaded ram.

9. Insert threaded ram through drilled hole; replace cutter on threaded ram.

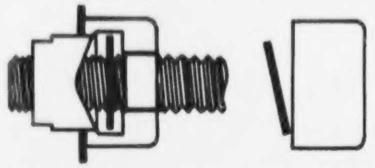
10. Close hydraulic valve; pump handle until cutter pulls through metal.

    (NOTE: After cutter is pulled through, knockout punch is easily removed.)

JOB SHEET #1

11. Open valve and remove cutter from threaded ram; shake out punched metal. (Figure 2)

FIGURE 2



Slug falls free in die

Tip die to remove slug

12. Replace cutter on ram, making sure that it is properly lubricated.

(NOTE: Have the instructor evaluate your work.)

13. Clean work area, and put away equipment and materials.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #2 — BEND A 90-DEGREE STUB USING A HYDRAULIC PIPE BENDER

A. Equipment and materials needed

1. Hydraulic pipe bender
2. 5 feet of 1-inch rigid galvanized conduit
3. Tape
4. Marking pencil

B. Procedure

(NOTE: The procedure that follows is specifically for a Greenlee #880 bender. Other benders may vary slightly in measurements, but the procedure will be basically the same.)

1. Assemble hydraulic bender using a 1-inch shoe and pipe supports.
2. Check chart on bender for minimum stub length, required deduction for stub, and ram travel measurement. Record data.
    a. Minimum stub length = ____________________
    b. Stub deduction = ____________________
    c. Ram travel = ____________________
3. Mark stub length (24 inches) on pipe.
4. Subtract stub deduction measurement from 24-inch mark, and make a second mark at that point.
5. Place pipe in bender shoe, matching center mark of shoe with second mark on pipe.
6. Close hydraulic pump valve, and pump handle until ram travel gauge indicates amount of travel for a 1-inch pipe with a 90-degree bend.
7. Release hydraulic pump valve, and allow ram to return fully before removing pipe.
8. Check height of stub and accuracy of 90-degree bend.

    (NOTE: Show work to instructor for evaluation.)
9. Disassemble bender, clean work area, and return equipment and materials to their proper places.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #3 — MAKE OFFSET AND 90-DEGREE BENDS USING AN ELECTRIC PVC HEATER

A. Equipment and materials needed

1. 10 feet of ½-inch PVC conduit

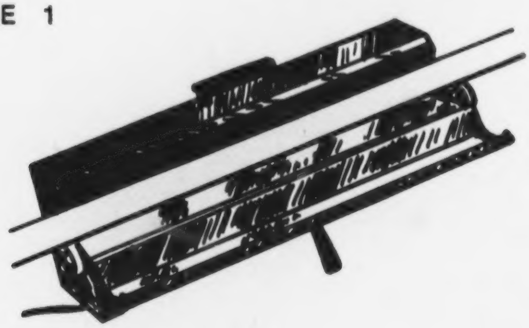
   (NOTE: Check code reference on minimum radius for PVC.)

2. Electric PVC heater
3. Instructions for PVC heater
4. Small pail of water
5. Shop rag or sponge
6. Piece of board at least 1 inch thick and as wide as desired offset
7. Nails to tack up piece of board
8. Eye protection
9. Gloves

B. Procedure — Heat conduit and make a 90-degree bend.

1. Read instructions for PVC heater.
2. Put on eye protection and gloves.
3. Plug in PVC heater and turn on; allow unit to preheat for fifteen minutes in closed position.
4. Open unit and insert PVC as shown in Figure 1.

FIGURE 1

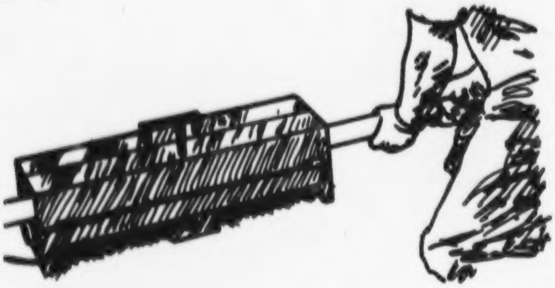


JOB SHEET #3

5. Close unit, and rotate PVC for one to two minutes or until it becomes pliable enough for bending. (Figure 2)

   (NOTE: Constantly turn conduit as it heats.)

   FIGURE 2



6. Remove PVC from heating chamber when it becomes soft and is easily bent.

   (NOTE: Experience will help in determining when PVC is pliable for bending. Make sure that conduit is adequately heated. Larger pieces of conduit tend to kink unless adequately heated.)

   (CAUTION: Conduit will be very hot. Handle it carefully to avoid burns.)

7. Turn off PVC heater.

8. Form the 90-degree bend by hand on a flat surface.

   (NOTE: Another method of forming the 90-degree bend is to push the conduit into a corner of the room, leaving the desired amount of straight conduit on each side of the bend.)

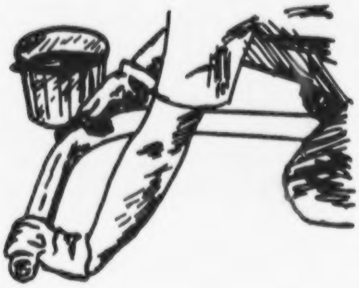
JOB SHEET #3

9. Apply water-soaked rag or sponge to PVC to set the bend (Figure 3)

   (CAUTION: Do not use water next to the electric heater because of shock hazard.)

   (NOTE: If bend is made in the corner of the room, an alternate method of setting the bend is to use straight boards to hold the conduit against the wall until it cools and hardens.)

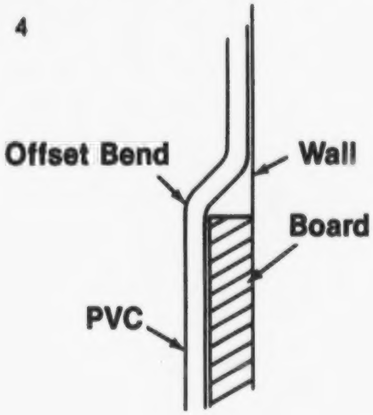
   FIGURE 3



C. Procedure — Heat conduit and make an offset bend.

1. Determine amount of offset desired.
2. Turn on PVC heater and allow it to preheat for fifteen minutes in closed position.
3. Nail prepared piece of board to wall so that PVC may be shaped by placing it against the wall and then bending it away from the wall to lie parallel to outer edge of board as shown in Figure 4.

   FIGURE 4



JOB SHEET #3

4. Open PVC heater, and insert PVC.

5. Close unit, and rotate PVC for one to two minutes or until it becomes pliable enough for bending.

6. Remove PVC from heating chamber when it becomes soft and is easily bent.

   (CAUTION: Conduit will be very hot. Handle it carefully to avoid burns.)

7. Turn off PVC heater.

8. Lay conduit against wall and against board as shown in Figure 4, holding the ends against the board and the wall until PVC cools and hardens.

   (NOTE: Show work to instructor for evaluation and comment.)

9. De-energize PVC heater.

10. Clean work area and put away all equipment and materials.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #4 — CUT, REAM, AND THREAD RIGID CONDUIT WITH A POWER THREADER

A. Equipment and materials needed

1. Power threader
2. Stand for power threader
3. Pipe cutter accessory
4. Pipe reamer accessory
5. Adjustable die head accessory
6. Tool carriage accessory
7. Carriage lever accessory
8. Instructions for power threader and accessories
9. Oiler and thread-cutting oil
10. Clean cloth
11. Eye protection
12. Gloves
13. Length of steel pipe

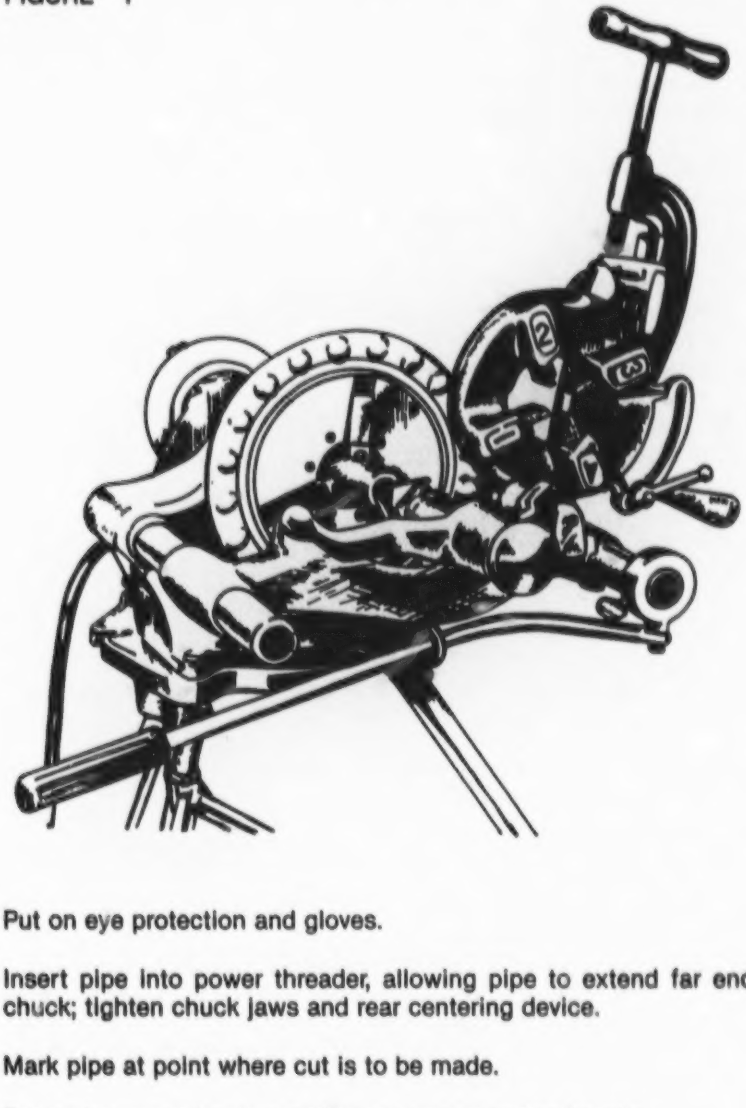
B. Procedure

1. Read instructions for power threader and accessories.
2. Install power threader on stand.

JOB SHEET #4

3. Install pipe cutter, pipe reamer, adjustable die head, tool carriage, and carriage lever on power threader. (Figure 1)

FIGURE 1



4. Put on eye protection and gloves.

5. Insert pipe into power threader, allowing pipe to extend far enough to clear chuck; tighten chuck jaws and rear centering device.

6. Mark pipe at point where cut is to be made.

7. Put tool support bar in position to support cutter handle.

8. Apply cutter to pipe, allowing cutter handle to rest on tool support bar.

9. Tighten cutter blade to contact pipe at marked point.

10. Energize power threader.

JOB SHEET #4

11. Turn power drive switch to FORWARD; turn cutter blade into pipe until pipe cut is completed.

12. Turn off motor, and lay cutter against tool rest.

13. Place reamer in pipe end, allowing reamer handle to rest against tool support bar.

14. Turn on motor.

15. Press reamer into pipe to remove burrs.

16. Turn off motor, and lay reamer against tool rest.

17. Place threader die head on pipe.

18. Cut required number of threads, keeping oil on die stock until threads are cut.

19. Turn off motor.

    (CAUTION: Always allow machine to come to a complete stop before reversing direction.)

20. Turn on motor, turn power drive switch to REVERSE, and remove threader from pipe.

21. De-energize power threader.

    (NOTE: Show threaded pipe to instructor for evaluation and comments.)

22. Dismantle equipment, clean work area, and put away all materials and equipment.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #5 — MEASURE RESISTANCE USING A VOM

A. Equipment and materials

1. Multimeter with test leads
2. Various resistors wrapped in masking tape to conceal their values, and numbered for reference

B. Procedure

(CAUTION: Never check resistance on a live circuit as this can severely damage the instrument.)

1. Position meter to correct function position.
2. Position meter range switch to one of the resistance scales.
3. Insert meter leads in correct meter jacks, observing polarity.
4. Connect meter across component to be checked.
5. Determine correct meter position closest to center scale or toward zero.
6. Remove leads from component and touch (short) leads together while using "Ohm's Zero Adjust" to position needle to the zero position.
7. Reconnect meter to component.
8. Read meter for Ohmic valve.

   (NOTE: Be sure to use proper scale, reading from right to left.)
9. Turn off meter.
10. Record your readings below:

    a. Resistor #1 ________________________________

    b. Resistor #2 ________________________________

    c. Resistor #3 ________________________________

    d. Resistor #4 ________________________________

    e. Resistor #5 ________________________________

    (NOTE: Show your results to the instructor.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #6 — MEASURE DC VOLTAGES USING A VOM

A. Equipment and materials needed

1. VOM with test leads
2. DC power source (power supply or battery)

B. Procedure

1. Position meter to correct function.

   EXAMPLES: -DC, +DC, or AC

2. Observing polarity, connect meter leads to meter.
3. Determine correct range scale.

   (NOTE: Use highest range if voltage is unknown.)

4. Turn power supply on.
5. Adjust the output to any voltage less than 50 volts.
6. Observing polarity, connect meter leads to circuit to be tested.

   (NOTE: Always hook VOM across the components or power source to be tested. If the indicator needle moves to the left, the lead polarity is wrong.)

7. Record results below:

   a. DC source = ______________________

   b. Voltage reading = ______________________

8. Change the source voltage or measure a second battery.

   a. DC source = ______________________

   b. Voltage reading = ______________________

   (NOTE: Show your results to your instructor.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #7 — MEASURE AC VOLTAGES USING A VOM

PART 1: Single-Phase Power Source

A. Equipment and materials needed

1. VOM with test leads
2. Alternating current power source

   EXAMPLE: Duplex receptacle

B. Procedure

1. Position meter to correct function.

   EXAMPLES: -DC, +DC, or AC

2. Observing polarity, connect meter leads to meter.
3. Determine correct range scale.

   (NOTE: Use highest range if voltage is unknown.)

4. Connect meter leads to circuit to be tested.

   (NOTE: Lead polarity is not important when measuring AC voltages because polarity changes at a rate of 60 cycles per second [USA].)

5. Measure "line voltage" of power receptacle. (See Figure 1)

   (CAUTION: 120 volts can cause injury or death. DO NOT touch the metal parts of the test leads while measuring.)

6. Set meter on lowest scale at which it will register.
7. Record the readings below.

   a. Voltage between slotted jacks ________________

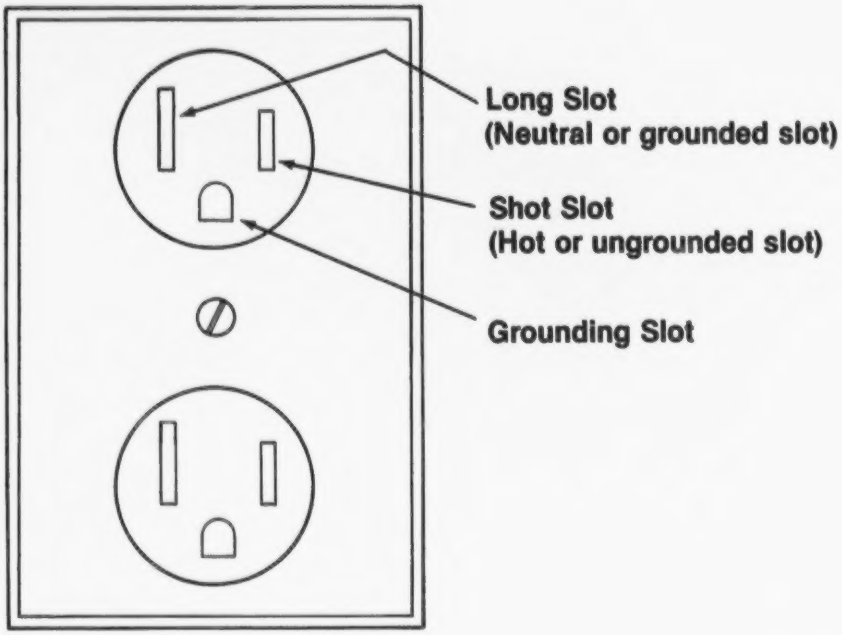
   b. Voltage between short slot and grounding slot ________________

   c. Voltage between long slot and ground slot ________________

8. Disconnect meter leads.
9. Turn off meter.

JOB SHEET #7

FIGURE 1


Long Slot
(Neutral or grounded slot)
Shot Slot
(Hot or ungrounded slot)
Grounding Slot

PART 2: Three-Phase Power Source

A. Equipment and materials needed

1. VOM with test leads
2. Source of three-phase AC power such as a fused disconnect
3. Safety glasses

B. Procedure

(NOTE: The instructor must supervise each student.)

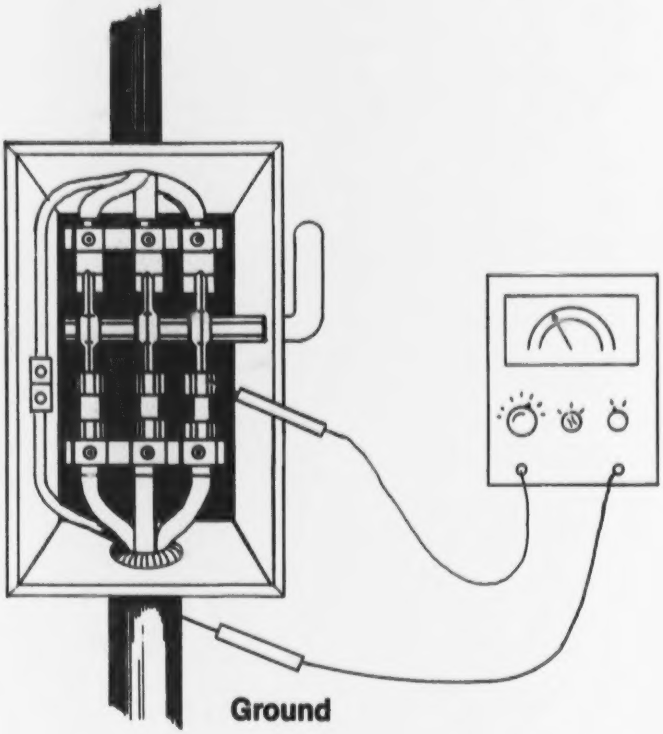
1. Set multimeter for AC voltage measurement.

   (NOTE: Be sure setting is correct.)

2. With instructor watching, *carefully* measure between each of the three terminals at the top of the disconnect and a ground terminal; record your measurements. (Figure 2)

JOB SHEET #7

FIGURE 2



Voltages from terminals to ground

a. ______________________________

b. ______________________________

c. ______________________________

3. Measure between first and second, first and third, and second and third terminals; record the readings below:

Voltages between terminals

a. 1 to 2 ______________________________

b. 1 to 3 ______________________________

c. 2 to 3 ______________________________

(NOTE: Show your measurements to your instructor.)

JOB SHEET #7

4. Disconnect meter leads.
5. Turn off meter.
6. Put equipment and materials away.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #8 — MEASURE AMPERAGE USING A CLAMP-ON AMMETER

A. Equipment and materials needed

1. Clamp-on ammeter

2. Source of three-phase AC power

B. Procedure

1. Position meter to highest scale.

2. Clamp the tongs around the live conductor.

   (CAUTION: Use extreme care when clamping the tongs around the conductor. Remember live circuits can KILL or INJURE you.)

   (NOTE: Place the tongs around only one conductor; failure to do so could result in inaccurate measurements.)

3. Reposition the scale to the lowest readable scale.

4. Record measurements below:

   a. Line 1 ______________________________

   b. Line 2 ______________________________

   c. Line 3 ______________________________

5. Put away equipment and materials.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #9 — DETERMINE THE CURRENT OF A MULTIPLE-LOOP CLAMP-ON AMMETER APPLICATION

A. Equipment and materials needed

1. Clamp-on ammeter

2. AC power source with a load (see the instructor)

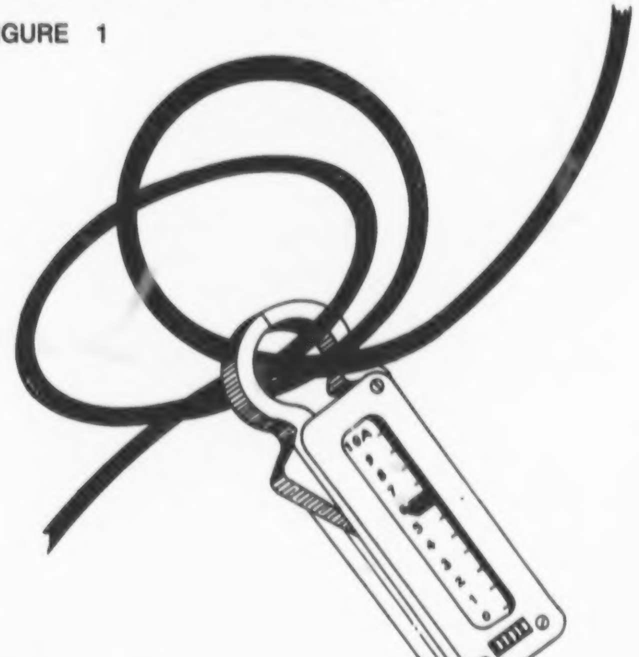
B. Procedure

1. Form three (3) loops in one conductor feeding the load.

2. Tape the loops tightly together.

3. Clamp the tongs through the loops. (Figure 1)

FIGURE 1



4. Read the meter and record.

Initial measurement = ______________________________

JOB SHEET #9

5. Divide reading by the number of loops (three) and record the actual current value.

   Actual current value = ______________________________

   (NOTE: Show your results to the instructor.)

6. Put equipment and materials away.

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

JOB SHEET #10 — CHECK CONDUCTOR INSULATION WITH A MEGGER

A. Equipment and materials needed

1. Megger
2. 20′ run of conduit with 3 #12 THHN conductors (one conductor should have a slight nick in the insulation approximately midway)
3. Pouch tools

B. Procedure

1. Isolate each conductor. Be sure conductor ends do not touch each other or the conduit.
2. Clamp the red lead to the conduit.
3. Clamp the black lead to one of the conductors.
4. Record reading.
5. Repeat steps 3 and 4 with the other two conductors.

   Conductor 1 ______________________________

   Conductor 2 ______________________________

   Conductor 3 ______________________________

6. From your readings, determine which conductor is bad.

   (NOTE: Show your results to the instructor.)

7. Put equipment and materials away.

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SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #1 — USE A HYDRAULIC KNOCKOUT PUNCH

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Put on gloves.	______	______
4. Assembled knockout punch correctly.	______	______
5. Drilled proper size hole.	______	______
6. Cut knockout properly.	______	______
7. Shook out punched metal.	______	______
8. Replaced knockout punch in case properly.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Drilled proper size hole	4	3	2	1
Hole in correct location	4	3	2	1
Punched metal removed	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #2 — BEND A 90-DEGREE STUB USING A HYDRAULIC PIPE BENDER

STUDENT'S NAME ________________________ DATE __________

EVALUATOR'S NAME ________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Put on safety glasses.	______	______
3.	Assembled bender properly.	______	______
4.	Checked bender chart.	______	______
5.	Performed subtraction properly.	______	______
6.	Bent 1" conduit properly.	______	______
7.	Replaced bender in case properly.	______	______
8.	Checked in/put away tools and materials.	______	______
9.	Cleaned the work area.	______	______
10.	Used proper tools correctly.	______	______
11.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12.	Practiced safety rules throughout procedure.	______	______
13.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

90° bend true	4	3	2	1
Pipe not crimped	4	3	2	1
Length of stub accurate	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #3 — MAKE OFFSET AND 90-DEGREE BENDS USING AN ELECTRIC PVC HEATER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Put on protective gloves.	______	______
4. Bent offset properly.	______	______
5. Bent 90° stub properly.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Offset correct	4	3	2	1
Offset not flattened	4	3	2	1
90-degree bend correct	4	3	2	1
90-degree bend not flattened	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #4 — CUT, REAM, AND THREAD RIGID CONDUIT WITH A POWER THREADER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Put on protective gloves.	______	______
4. Cut pipe properly.	______	______
5. Reamed pipe properly.	______	______
6. Threaded pipe properly.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Threaded to proper length	4	3	2	1
Reamed pipe correctly	4	3	2	1
Threads true and clean	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #5 — MEASURE RESISTANCE USING A VOLT-OHM-METER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Positioned meter to correct function.	______	______
4. Inserted lead properly (polarity).	______	______
5. Zero adjusted meter.	______	______
6. Read meter correctly (proper scale).	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #5 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Obtained accurate meter readings				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #6 — MEASURE DC VOLTAGES USING A VOM

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Set meter correctly for DC measurements.	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #6 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Obtained correct DC measurements				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY
4 — Skilled — Can perform job with no additional training. 3 — Moderately skilled — Has performed job during training program; limited additional training may be required. 2 — Limited skill — Has performed job during training program; additional training is required to develop skill. 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #7 — MEASURE AC VOLTAGES USING A VOM

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Set meter correctly for AC measurements.	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #7 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Obtained correct AC measurements				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #8 — MEASURE ALTERNATING CURRENT USING A CLAMP-ON AMMETER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Chose proper scale.	______	______
4. Repositioned to lowest readable scale.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #8 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Obtained correct readings				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #9 — DETERMINE THE CURRENT OF A MULTIPLE-LOOP CLAMP-ON AMMETER APPLICATION

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Formed proper number of loops.	______	______
4. Taped loops.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #9 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Obtained correct reading				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

PRACTICAL TEST
JOB SHEET #10 — CHECK CONDUCTOR INSULATION WITH A MEGGER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Put on safety glasses.	______	______
3. Connected leads correctly.	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #10 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Recorded readings correctly	4	3	2	1
Determined bad conductor correctly	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

TEST

NAME ____ SCORE ________________

1. Match the terms on the right with their correct definitions.

_____a. Electromotive force (emf), force that drives electricity through conductors; must be measured across or referenced to a second point.

_____b. Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

_____c. Device used to transfer hydraulic pressure to a mechanical device

_____d. How well an instrument will indicate a small change in the measured value

_____e. Instrument consistency

_____f. Instrument capable of measuring a "multiple" of values

_____g. Any opening that may close and bind a finger or hand

_____h. Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

_____i. Plastic pipe

_____j. Device used to make openings for conduit in metal enclosures

_____k. Component that backs up cutter on opposite side of metal box

_____l. How far the measurement is from the actual value

_____m. Portion of drill that holds the bit

_____n. Tool used to make various angles or bends in conduit

1. Accuracy
2. Amperage
3. Bender
4. Calibration
5. Chuck
6. Cross handle
7. Cutter
8. Die
9. Error
10. Ground
11. Hydraulic
12. Hydraulic oil
13. Knockout punch
14. Multimeter
15. Parallax correction
16. Pinch point
17. Polyvinyl chloride (PVC)
18. Precision
19. Ram (PVC)
20. Resistance
21. Resolution
22. Voltage

TEST

_____o. Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

_____p. How near the instrument reading is to the actual value

_____q. Handle set across a power tool to prevent the tool from turning

_____r. Hardened steel device used to cut holes in metal boxes

_____s. Technique of testing and adjusting an instrument by referring it to another instrument or device of known accuracy and precision

_____t. Using pressurized fluid to accomplish work

_____u. Specially formulated oil for hydraulic pumps

_____v. Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

2. List typical power equipment below.

a. ____

b. ____

c. ____

d. ____

e. ____

3. Select true statements concerning general safety rules for using power equipment by placing an "X" in the blanks preceding the true statements.

_____a. Follow manufacturer's operating instructions when possible.

_____b. Never place hands in pinch point.

_____c. Use eye protection.

_____d. Wear gloves when working with hot equipment or materials.

_____e. Always secure loose clothing such as shirt sleeves and shirttails.

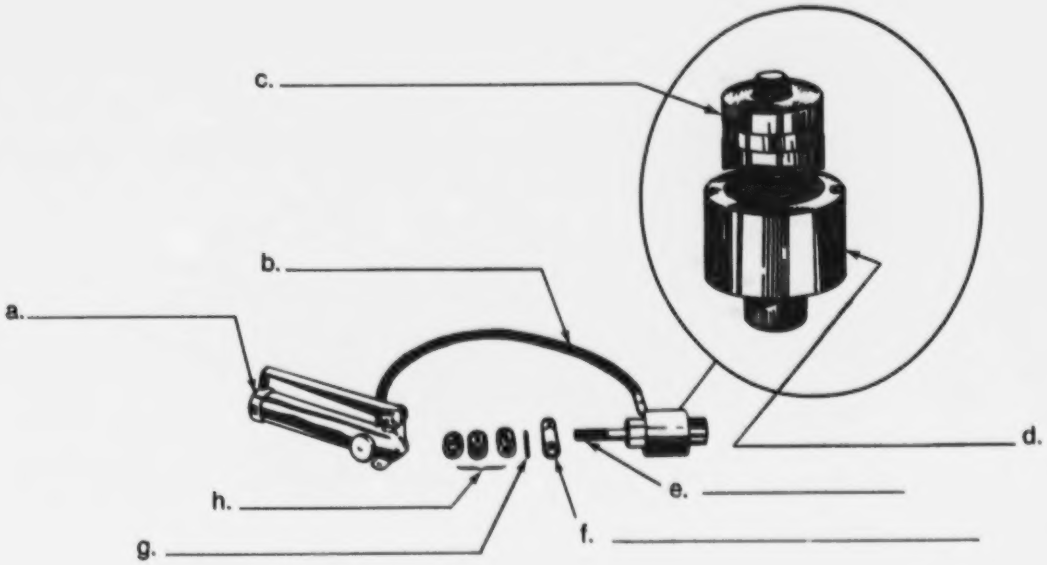
_____f. Exceed rated capacity of equipment if you are behind schedule.

_____g. Leave running equipment unattended.

_____h. Remove protective guards from equipment when they get in the way.

TEST

4. Label the parts of the hydraulic knockout set illustrated below.



5. Complete the following statements concerning specific safety rules for using hydraulic knockout sets by inserting the word(s) that best complete each statement.

   a. Never substitute brake fluid for ____________ ____________ .

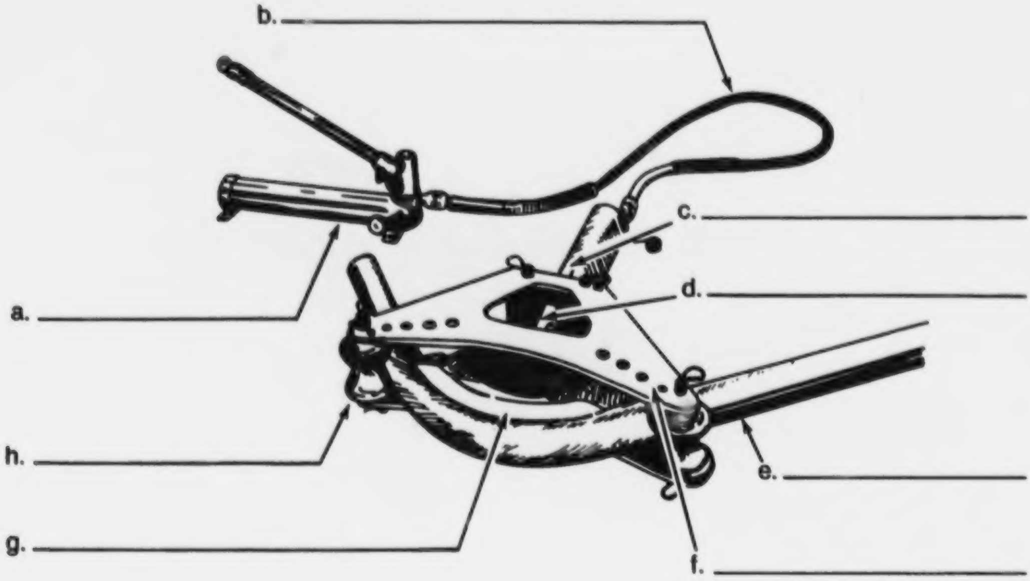
   b. Never disconnect hose when it is ____________ ____________ .

   c. Do not use near ____________ electrical parts.

   d. Never ____________ pump handle.

TEST

6. Label the parts of the hydraulic pipe bender illustrated below.



7. Select true statements concerning specific safety rules for using hydraulic pipe benders by placing an "X" in the blanks preceding the true statements.

_____a. Substitute brake fluid for hydraulic oil.

_____b. Never disconnect hose when it is under pressure.

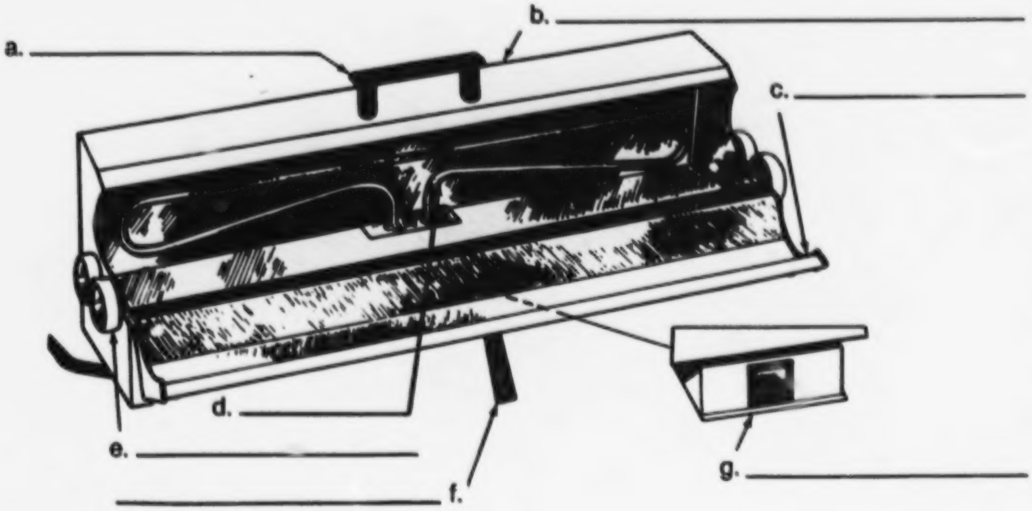
_____c. Never place hands near ram or shoe while bending.

_____d. Always use proper side of conduit shoe and support.

_____e. Be sure that floor area is clear for pipe movement.

TEST

8. Label the parts of a polyvinyl chloride (PVC) heater illustrated below.



9. Complete the following statements concerning specific safety rules for using electric polyvinyl chloride (PVC) heaters by circling the word that best completes each statement.

   a. Never use in **(dry, wet)** locations.

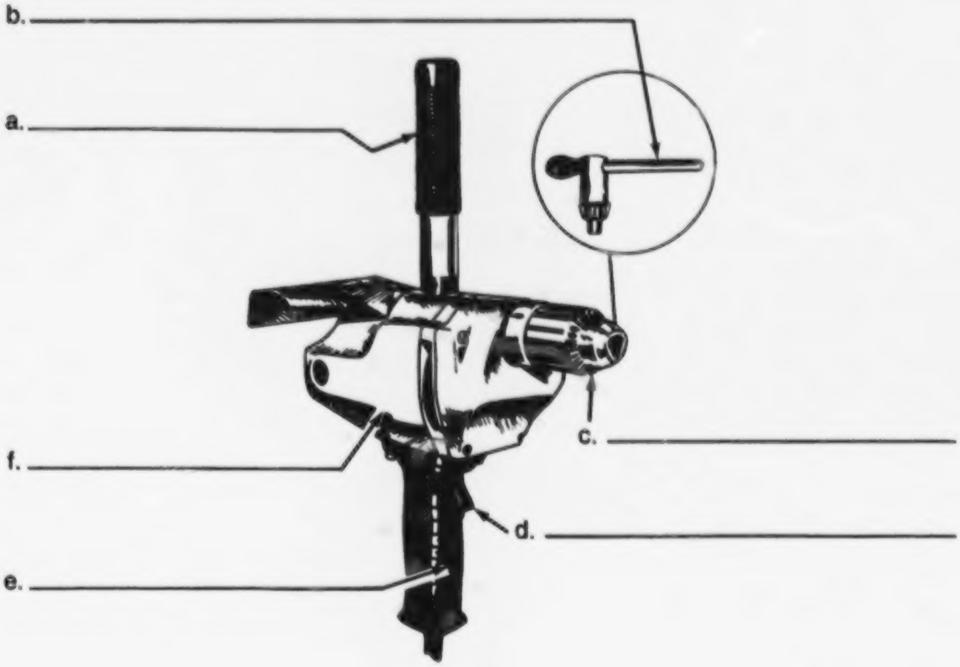
   b. Always wear **(safety glasses, gloves)** when handling hot heater or pipe.

   c. Use only with **(PVC, EMT)** conduit.

   d. **(Always, Occasionally)** turn bender off when not in use.

TEST

10. Label the parts of the power drill illustrated below.



11. Select true statements concerning specific safety rules for using power drills by placing an "X" in the blanks preceding the true statements.

_____a. Always wear gloves.

_____b. Check area to be drilled for hidden wires or pipes.

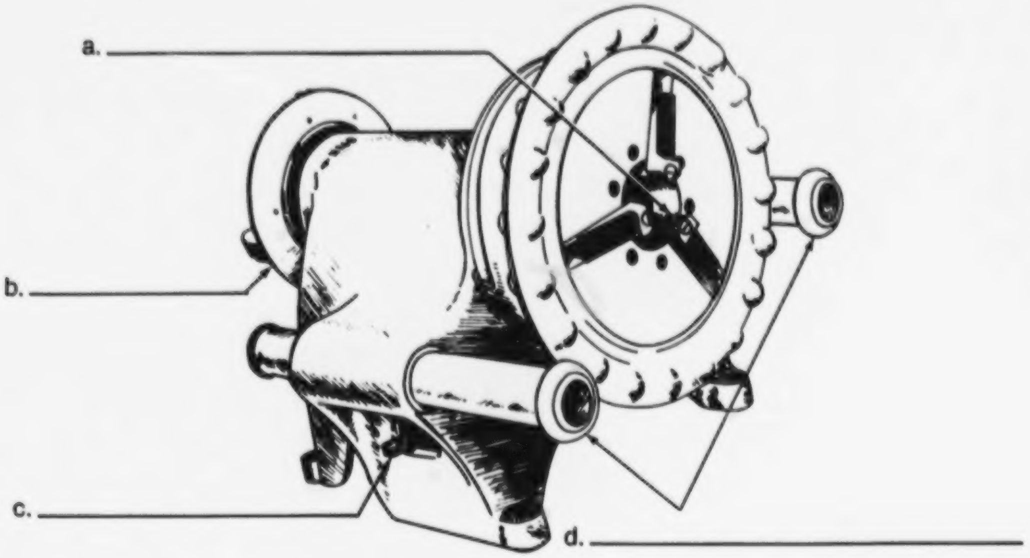
_____c. Hold drill securely with one hand.

_____d. Never drill while off balance.

_____e. Place all objects to be drilled in a vise.

TEST

12. Label the parts of the power threader illustrated below.



13. Complete the following statements concerning specific safety rules for using power threaders by inserting the word(s) which best complete each statement.

    a. Always wear ____________ .

    b. Always wear ____________ clothing.

    c. Use ____________ when handling pipe.

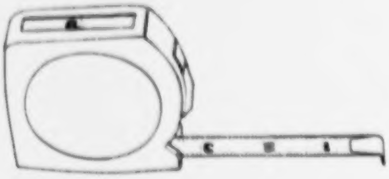
    d. Never place ____________ near turning pipe.

    e. Let threader come to a complete stop before removing pipe or ____________ .

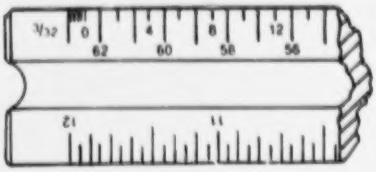
    f. Always use a ____________ to clear thread cuttings.

TEST

14. Identify the typical rules and scales illustrated below.

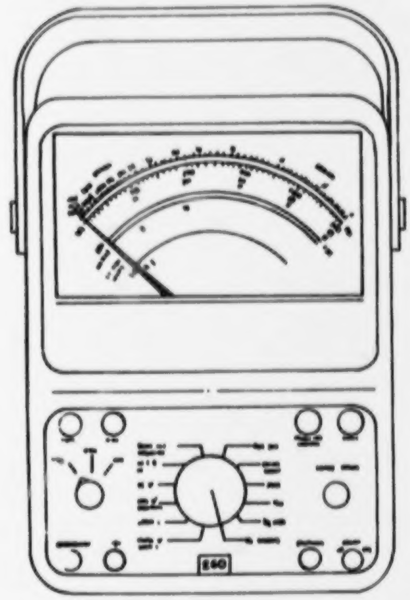


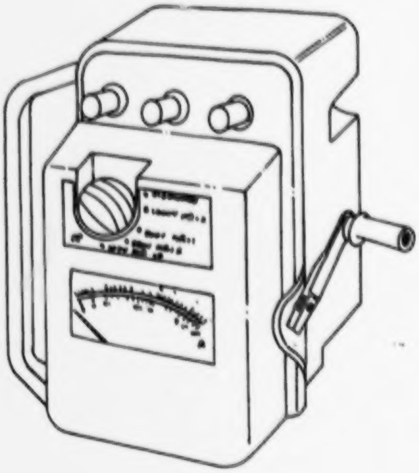
a. ______________________________


1/32
0
4
8
12
62
60
58
56
12
11

b. ______________________________

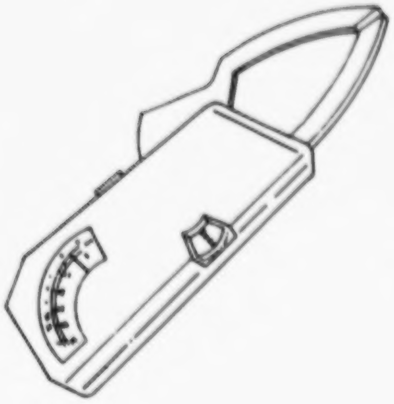
15. Identify the typical test equipment illustrated below.



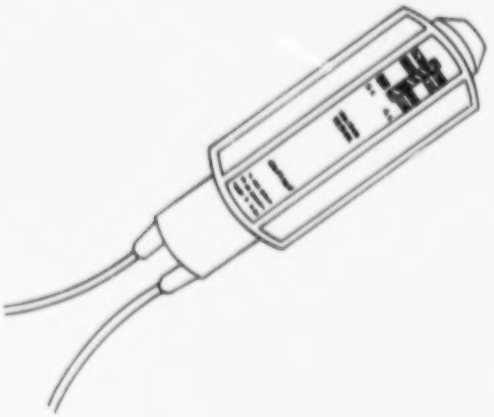


a. ______________________________ b. ______________________________

TEST



c. ______________________



d. ______________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

16. Measure objects using a rule. (Assignment Sheet #1)

17. Determine lengths of lines using an architect's scale. (Assignment Sheet #2)

18. Demonstrate the ability to:

    a. Use a hydraulic knockout punch. (Job Sheet #1)

    b. Bend a 90-degree stub using a hydraulic pipe bender. (Job Sheet #2)

    c. Make offset and 90-degree bends using an electric PVC heater. (Job Sheet #3)

    d. Cut, ream, and thread rigid conduit with a power threader. (Job Sheet #4)

    e. Measure resistance using a VOM. (Job Sheet #5)

    f. Measure DC voltages using a VOM. (Job Sheet #6)

    g. Measure AC voltages using a VOM. (Job Sheet #7)

    h. Measure amperage using a clamp-on ammeter. (Job Sheet #8)

    i. Determine the current of a multiple-loop clamp-on ammeter application. (Job Sheet #9)

    j. Check conductor insulation with a megger. (Job Sheet #10)

SPECIALTY TOOLS AND EQUIPMENT
UNIT V

ANSWERS TO TEST

1.

a.	22	f.	14	k.	8	p.	1	u.	12
b.	20	g.	16	l.	9	q.	6	v.	15
c.	19	h.	10	m.	5	r.	7		
d.	21	i.	17	n.	3	s.	4		
e.	18	j.	13	o.	2	t.	11		

2.
a. Hydraulic knockout
b. Hydraulic bender
c. Electric PVC heater
d. Power drill
e. Power threader

3. b, c, d, e

4.
a. Hydraulic pump
b. Hydraulic hose
c. Knockout cutter
d. Die
e. Hydraulic threaded ram
f. Screw sleeve
g. ½-inch knockout adapter
h. Spacers

5.
a. Hydraulic oil
b. Under pressure
c. Live
d. Force

6.
a. Hydraulic pump
b. Hydraulic hose
c. Ram travel gauge
d. Hydraulic ram
e. Pipe
f. Bender frame
g. Bender shoe
h. Pipe support

7. b, c, d, e

8.
a. Carrying handle
b. Heater outer case
c. Door
d. Heating element
e. Pipe rollers
f. Insulated door handle
g. On/off switch

ANSWERS TO TEST

9. a. Wet
b. Gloves
c. PVC
d. Always

10. a. Cross handle
b. Chuck key
c. Chuck
d. Power trigger
e. Reverse/forward switch
f. Drill motor

11. b, d

12. a. Front pipe chuck
b. Rear pipe chuck
c. Forward/reverse/off switch
d. Tool support bars

13. a. Eye protection
b. Tight-fitting
c. Gloves
d. Hands
e. Reversing direction
f. Brush

14. a. Sixteen foot tape
b. Architect's scale

15. a. Voltage tester
b. Multimeter (VOM)
c. Clamp-on ammeter
d. Megometer (megger)

16.-17. Evaluated to the satisfaction of the instructor

18. Performance skills evaluated to the satisfaction of the instructor.

USING TRADE INFORMATION
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to locate specific wiring and installation information in the National Electrical Code. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to using trade information with their correct definitions.
2. State the purpose of the National Electrical Code.
3. List factors that are not covered by the NEC.
4. State the intent of the NEC regarding mandatory enforcement.
5. Match NEC chapter numbers with their correct areas of application.
6. Arrange in order the sequence of organizational components of National Electrical Code information.
7. Arrange in order the steps for finding information in the NEC.
8. Use the National Electrical Code (NEC) index. (Assignment Sheet #1)
9. Use the National Electrical Code (NEC) introduction and first chapter. (Assignment Sheet #2)
10. Answer questions related to residential wiring practices using the NEC as a reference. (Assignment Sheet #3)

OBJECTIVE SHEET

11. Locate allowable ampacities for various conductors using the NEC as a reference. (Assignment Sheet #4)

12. Interpret conduit fill tables using the NEC as a reference. (Assignment Sheet #5)

13. Find information in the NEC. (Assignment Sheet #6)

USING TRADE INFORMATION
UNIT VI

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Provide students with objective sheet.

C. Discuss unit and specific objectives.

D. Provide students with information and assignment sheets.

E. Discuss information and assignment sheets.

F. Integrate the following activities throughout the teaching of this unit:

1. Provide students with a copy of the National Electrical Code and stress its importance.

2. Prepare activity sheets covering service drop clearance, sizing grounded conductors, and working clearances for use as a group activity in finding and interpreting the appropriate codes.

   (NOTE: A good source for activities is *Illustrated Changes of the 1987 NEC* by James G. Stallcup. See reference list.)

3. Invite a local inspector to speak to the class.

4. Provide students with copies of local codes.

5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

G. Give test.

H. Evaluate test.

I. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *National Electrical Code, 1987.* Quincy, MA: National Fire Protection Association, 1986.

B. Stallcup, James G. *Illustrated Changes of the 1987 NEC.* Homewood, IL: American Technical Publishers, Inc., 1986.

C. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

D. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

SUGGESTED SUPPLEMENTAL MATERIAL

Text — Schram, Peter J. *The National Electrical Code Handbook, 1987.* Quincy, MA: National Fire Protection Association, 1986.

USING TRADE INFORMATION
UNIT VI

INFORMATION SHEET

I. **Terms and definitions**

A. American National Standards Institute (ANSI) — Develops standards for electrical equipment and supplies

B. American Standard Association (ASA) — Develops standards for electrical machinery and equipment

C. Bonding — Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

D. Bonding jumpers — Pieces of wire or other conductors that connect different metal parts

E. Bonding jumper circuit — Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

F. Bonding jumper equipment — Connections between two or more portions of the equipment grounding conductors

G. Building code — Standards developed to provide for safe building construction practices

H. Grounded — Connected to earth or to some conducting body that serves in place of the earth

I. Grounded conductor — Intentionally grounded system or circuit conductor (neutral)

J. Grounding conductor — Conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

K. Grounding electrode conductor — Conductor used to connect the grounding electrode to the equipment grounding conductor or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system

L. Jurisdiction — Power, right, or authority to interpret the law (code)

M. Mandatory enforcement — Governmental authority to demand compliance with the National Electrical Code requirements for electrical installations

N. National Electrical Code (NEC) — Book containing electrical specifications endorsed by NFPA and ANSI; used for legal and regulatory purposes in the interest of life and property protection

INFORMATION SHEET

O. National Electrical Manufacturers Association (NEMA) — Develops electrical equipment standards

P. National Fire Protection Association (NFPA) — Develops and publishes fire and industrial safety standards

Q. Underwriters Laboratories (UL) — Test equipment and list items for use in specified situation

(NOTE: There are other approved testing labs.)

II. **Purpose of the National Electrical Code** — Sets minimum standards for safeguarding persons and property from hazards arising from the use of electricity

III. **Factors that are not covered by the NEC**

A. Efficiency

B. Convenience

C. Good service

IV. **Intent of the National Electrical Code regarding mandatory enforcement** — The code is intended to be suitable for mandatory enforcement by the governmental authority having jurisdiction. Mandatory rules are characterized by the word "SHALL"

(NOTE: The legal inspector may grant exceptions [special permission] to code requirements, provided safety standards are maintained. States and municipalities may adopt their own electrical codes as long as these codes improve upon, not lessen the requirements of the NEC.)

V. **NEC chapter numbers and their areas of application**

A. Chapters 1 through 4 — General application, may be modified in later chapters

B. Chapter 5 — Hazardous locations

C. Chapter 6 — Special equipment

D. Chapter 7 — Special conditions

E. Chapter 8 — Communications systems

F. Chapter 9 — Tables and examples

INFORMATION SHEET

VI. **Sequence of organizational components of NEC information**

A. **Chapter** — Covers broad area of code

EXAMPLE:: Chapter — Wiring Design and Protection

B. **Article** — Covers a specific part of the chapter

EXAMPLE: Article 210 — Branch circuits

C. **Parts** — Covers a specific item of the article

EXAMPLE: Part B — Branch circuit ratings

D. **Numbered paragraphs** — Cover a specific item of the part

EXAMPLE: Paragraph 19 — Conductors — Minimum ampacity and size

E. **Numbered (1) or lower case lettered (a) subparagraphs**

EXAMPLE: Subparagraph [b] — Household ranges and cooking appliances

VII. **Steps for finding imformation in the NEC**

(NOTE: The examples following the steps concern the proper method of grounding a service entrance panel.)

A. Refer to index for appropriate area of code.

EXAMPLE: Service entrance equipment

B. Locate specified area in question.

EXAMPLE: Grounding of services

C. Turn to article and section as designated

EXAMPLE: Service equipment — grounding — 230-63
Multiple circuit connections — 250-62

D. Read all related areas and exceptions.

INFORMATION SHEET

E. Cross-reference if code refers to another article.

EXAMPLE: Service-entrance eqiupment (Disconnecting means and overcurrent protection)

- Definition, Art. 100
- Disconnecting means, 230-H
    - Approved type, 230-70
    - Connections ahead of, 230-82
    - Connections to terminals, 230-81
    - Disconnection of grounded conductor, 230-75
    - Electrically operated, 230-94, Ex. 6
    - Externally operable, 230-78
    - Ground-fault, protection at, 230-95
    - Indicating, 230-77
    - Location, 230-72(c), (d)
    - Multiple occupancy buildings, 230-72(d)
    - Over 600V, 230-205, 230-206
    - Rating, 230-79
    - Safeguard, emergency supply, 230-83
    - Simultaneous openings, 230-74
    - Six switch rule, 230-71
    - Two or more buildings, single management, 230-84
- Grounding, bonding, guarding, 230-G, 230-63, 250-62
- Overcurrent protection, 230-J
    - Location, 230-91, 230-92
    - Over 600V, 230-208
    - Relative location, 230-94
    - Specific circuits, 230-93
    - Two or more buildings, single management, 230-90(c)
    - Undergrounded conductors, 230-90(a)
- Panelboards, as, 384-B

(NOTE: It is imperative that all cross references be found and read, otherwise the improper answer may be used.)

USING TRADE INFORMATION
UNIT VI

ASSIGNMENT SHEET #1 — USE THE *NATIONAL ELECTRICAL CODE* (NEC) INDEX

NAME ________________________ SCORE ____________

The electrician must be able to use the *Code* in order to answer questions on proper wiring procedures.

Directions: Use the *National Electrical Code* index to answer the following questions. Write the correct answers in the blanks.

A. What article covers aircraft hangers?

Article ____________

B. What section covers bonding jumpers?

Code section ____________

C. What section covers boxes over 600 volts?

Code section ____________

D. What section covers support of busways?

Code section ____________

E. What section covers light fixtures in clothes closets?

Code section ____________

F. What section covers the clearances of recessed lighting fixtures?

Code section ____________

G. What section covers overload protection in panelboards?

Code section ____________

H. What section covers appliance accessibility in recreational vehicles?

Code section ____________

I. What section covers construction specifications for rheostats?

Code section ____________

J. What sections cover guarding and grounding on x-ray equipment?

Code sections ____________ and ____________

USING TRADE INFORMATION
UNIT VI

ASSIGNMENT SHEET #2 — USE THE *NATIONAL ELECTRICAL CODE* (NEC) INTRODUCTION AND FIRST CHAPTER

NAME ________________________ SCORE ____________

Directions: Find the following information using the *National Electrical Code* table of contents, introduction, and first chapter. Indicate the code section number(s) that apply to each statement.

A. The purpose of this code is the practical ______________ of persons and property from hazards arising from the use of electricity.

Code section ______________

B. Tables and examples are found in ____________ ____________

C. Define the following terms. *Code* section ______________

1. Ampacity — ________________________________
2. Branch circuit — ________________________________
3. Outlet — ________________________________
4. Service cable — ________________________________
5. Bonding — ________________________________

ASSIGNMENT SHEET #2

6. Covered conductor — ______

7. Receptacle — ______

8. Service drop — ______

9. Device — ______

10. Disconnecting means — ______

11. Equipment — ______

12. Overload — ______

13. Service lateral — ______

ASSIGNMENT SHEET #2

14. Thermally protected — ____________________

15. Weatherproof — ____________________

16. Ventilated — ____________________

17. Thermal cutout — ____________________

18. Service raceway — ____________________

19. Readily accessible — ____________________

20. Enclosed — ____________________

USING TRADE INFORMATION
UNIT VI

ASSIGNMENT SHEET #3 — ANSWER QUESTIONS RELATED TO RESIDENTIAL WIRING PRACTICES USING THE NEC AS A REFERENCE

NAME ______________________________ SCORE ____________

Directions: Give article number and answer to questions.

(NOTE: The problem solving steps listed below are taken from Objective VII on the Information Sheet.)

EXAMPLE: Are ground-fault circuit interrupters required on 125 volt single phase 20 amp temporary construction receptacles

Step 1: Refer to index: "Ground-Fault Interrupters" is located and "Construction Sites" is listed.

Step 2: Note listing of article.

Step 3: Turn to table of contents and locate article number.

Step 4: Read across to page number.

Step 5: Find the page number for the article on branch circuits; turn to it.

Step 6: Find section number by turning pages in article.

Answer: From the article on branch circuits, 20 amp receptacles on temporary poles do require ground-fault circuit interrupters.

Problems

1. Do boxes made of metal need to be corrosion resistant?

   Answer:

2. What is the definition of "ampacity"?

   Answer:

3. Can a branch circuit used for lighting purposes and rated at 20 amps have a 12 amp dishwasher or other fixed appliance connected to it?

   Answer:

USING TRADE INFORMATION
UNIT VI

ASSIGNMENT SHEET #4 — LOCATE ALLOWABLE AMPACITIES FOR VARIOUS CONDUCTORS USING THE NEC AS A REFERENCE

NAME ______________________________ SCORE ____________

Directions: List the various ampacities for the conductors as listed using Table 310-16 through 310-17.

EXAMPLE: List the ampacities for the following conductors when used in a 3 conductor cable with an ambient temperature of 100°F.

1. #12 TW copper ______
2. #6 TW copper ______

Answers:
1. 25 amps (cannot be fused over 20 amps)
2. 55 amps

Problems:

What is the allowable ampacity for the following single insulated copper conductors used in free air if the ambient temperature is 90°F?

1. 14 TW ______

2. 1 TW ______

3. 1 THWN ______

4. 10 THW ______

What is the allowable ampacity for the following aluminum conductors when used in a 3 wire cable, if the ambient temperature is 70°F?

5. 10 TW ______

6. 12 TW ______

7. 1/0 TW ______

8. 6 TW ______

USING TRADE INFORMATION
UNIT VI

ASSIGNMENT SHEET #5 — INTERPRET CONDUIT FILL TABLES USING THE NEC AS A REFERENCE

NAME ________________________________ SCORE ______________

Directions: List the maximum number of conductors allowed in the following conduits.

½" conduit

1. 14 THHN ______
2. 10 THWN ______
3. 6 TW ______

¾" conduit

4. 10 THWN ______
5. 4 THWN ______

1" conduit

6. 6 TW ______
7. 3 TW ______
8. 6 THWN ______

2" conduit

9. 4/0 THWN ______
10. 4/0 TW ______

USING TRADE INFORMATION
UNIT VI

ASSIGNMENT SHEET #6 — FIND INFORMATION IN THE NEC

NAME ____________________ SCORE __________

PART I

Directions: Use the *National Electrical Code*, Article 250, to find the following information. Write the correct answers in the appropriate blanks.

A. Article 250-1 covers general and specific requirements for grounding and bonding of electrical installation.

List the six specific requirements detailed in the *Code*.

Article part __________ *Code* section __________

1. ______________________________
____
2. ______________________________
____
3. ______________________________
____
4. ______________________________
____
5. ______________________________
____
6. ______________________________
____

B. Portable generators (in some instances) are not required to be grounded to earth.

Article part __________ *Code* section __________

True __________ False __________

ASSIGNMENT SHEET #6

C. In grounding separately derived AC systems, "the grounding electrode shall be as near as practicable to and preferably in the same area as the grounding conductor connection to the system."

Article part ____________ *Code* section ____________

True ____________ False ____________

D. "Bonding shall be ________________ where necessary to assure electrical continuity and the capacity to conduct safely any ____________ ____________ likely to be imposed."

Article part ____________ *Code* section ____________

E. "The metal covering of service cable having an ________________ grounded service conductor in continuous electrical contact with its metallic armor or tape shall be considered to be grounded."

Article part ____________ *Code* section ____________

F. "An equipment bonding ________________ shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box." How many exceptions are there? ________________

Article part ____________ *Code* section ____________

G. "Main and equipment bonding jumpers shall be of ________________ or other corrosion-resistant material."

Article part ____________ *Code* section ____________

H. "The size of copper, aluminum, or copper-clad aluminum equipment grounding conductors shall not be less than given in Table 250-95." Give the sizes of copper equipment grounding conductors for 100-ampere, 200-ampere, and 400-ampere circuits.

Article part ____________ *Code* section ____________

100 A = ____________

200 A = ____________

400 A = ____________

I. "________________ or ________________ of instrument transformers shall be grounded where accessible to other than qualified persons."

Article part ____________ *Code* section ____________

ASSIGNMENT SHEET #6

J. In making grounding conductor connections, "required grounding conductors and bonding jumpers shall be connected by pressure connectors, clamps, or other approved means. Connection devices or fittings that depend on solder shall ______________ be used."

Article part ____________ *Code* section ____________

PART II

Directions: Use the *National Electrical Code*, Articles 336 through 364, to find the following information. Write the correct answers in the appropriate blanks.

A. Type NM cable shall not be run in a shallow chase in masonry walls.

True ____________ False ____________ *Code* section ____________

B. Protective guard strips are required for Romex and NM cable within 7 feet of the nearest edge of an accessible attic entrance; however, where the space is not accessible by permanent stairs or ladders, the guard strips shall be within ____________ feet of the attic entrance.

Code section ____________

C. Intermediate metal conduit is not acceptable as an equipment grounding conductor.

True ____________ False ____________ *Code* section ____________

D. Aluminum fittings and enclosures are permitted on steel rigid metallic conduit runs.

True ____________ False ____________ *Code* section ____________

E. Rigid metallic conduit threads are to be tapered at ¾ inch per foot.

True ____________ False ____________ *Code* section ____________

F. Rigid nonmetallic conduit sizes ½ inch to 1 inch are to be supported at 3-foot intervals.

True ____________ False ____________ *Code* section ____________

G. Electrical metallic tubing (EMT) conduit shall not be threaded.

True ____________ False ____________ *Code* section ____________

H. Flexible metallic tubing runs shall not be over 6 feet.

True ____________ False ____________ *Code* section ____________

ASSIGNMENT SHEET #6

I. Three-eighths-inch flexible metal conduit runs are limited to 6 feet in length.

True ____________ False ____________ *Code* section ____________

J. A busway is considered to be a grounded metal enclosure containing factory-mounted bare or insulated conductors.

True ____________ False ____________ *Code* section ____________

PART III

Directions: Use the *National Electrical Code*, Articles 430 through 501, to find the following information. Write the correct answers in the appropriate blanks.

A. In marking motors, the nameplate is to show both voltage and full-load current; for multispeed motors, the nameplate is to show full-load amperage for each speed.

True ____________ False ____________ *Code* section ____________

B. The circuit of a control apparatus that carries the electric signals directing the performance of the controller, but does not carry the main power current, is called ____________ ____________ ____________

Code section ____________

C. The disconnecting means for a torque motor shall have an ampere rating of 125 percent of the motor nameplate current.

True ____________ False ____________ *Code* section ____________

D. The branch circuit for an air conditioner compressor unit may have a short circuit protection device rated at 225 percent of the motor-rated load.

True ____________ False ____________ *Code* section ____________

E. The ampacity of generator phase wires to the first overcurrent device shall not be less than 125 percent of the nameplate current rating.

True ____________ False ____________ *Code* section ____________

F. Water pipes intended for vault fire protection or transformer cooling are permitted in a transformer vault.

True ____________ False ____________ *Code* section ____________

G. A sealed cell or battery may have a vent opening but no opening to add battery fluid.

True ____________ False ____________ *Code* section ____________

ASSIGNMENT SHEET #6

H. Class 1 hazardous locations are those having to do with hazardous gases or vapors.

True ____________ False ____________ *Code* section ____________

I. Conduit seals in Class 1, Division 1, hazardous locations may be 24 inches from an enclosure for switching.

True ____________ False ____________ *Code* section ____________

PART IV

Directions: Use the *National Electrical Code* to find the following information. Answers may be found throughout the *Code*.

A. Generally, service entrance conductors shall not be spliced. How many exceptions to this rule are permitted?

Number ____________ *Code* section ____________

B. A #18 fixture wire is considered to be protected by a 200-ampere breaker.

True ____________ False ____________ *Code* section ____________

C. "Conduit bodies having provisions for less than three conduit entries shall not contain splices, taps, or devices unless they comply with the provisions of *Code* section 370-6(b) and are supported in a rigid and secure manner."

True ____________ False ____________ *Code* section ____________

D. "In completed installations each outlet box shall have a cover, ______________, or fixture canopy."

Code section ____________

E. "The allowable ampacities in Tables 310-16 through 310-19 are based on temperature alone and do not take voltage drop into consideration."

True ____________ False ____________ *Code* section ____________

F. Where type NM cable (Romex) is installed in accessible attics, "the installation of cable in accessible attics or roof spaces shall comply with *Code* section ____________."

Code section ____________

ASSIGNMENT SHEET #6

G. Capacitors 600 volts nominal and under shall be provided with a means of draining the stored charge to 50 volts or less within ____________ ________________ after being disconnected from power source.

Code section ____________

H. Hazardous locations Class II are those that are hazardous because of the presence of combustible dust.

True ____________ False ____________ *Code* section ____________

I. "All 120-volt receptacles located within 15 feet of the inside walls of a swimming pool shall be protected by a ground-fault circuit-interrupter."

True ____________ False ____________ *Code* section ____________

USING TRADE INFORMATION
UNIT VI

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. 513
B. 250-79
C. 370-D
D. 364-5
E. 410-8
F. 410-8
G. 384-16
H. 551-24
I. 430-82(c)
J. 517-151, 660-D

Assignment Sheet #2

A. Safeguarding; code section 90-1(a)
B. Chapter 9
C. Code section 100-A
    1. "Current-carrying capacity of electric conductors expressed in amperes"
    2. "The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s)"
    3. "A point on the wiring system at which current is taken to supply utilization equipment"
    4. "Service conductors made up in the face of a cable"
    5. "The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed."
    6. "A conductor encased within material of composition or thickness that is not recognized by this Code as electrical insulation"
    7. "A contact device installed at the outlet for the connection of a single attachment plug"
    8. "The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure"
    9. "A unit of an electrical system which is intended to carry but not utilize electric energy"
    10. "A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of plenty"
    11. "A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation"
    12. "Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload"

ANSWERS TO ASSIGNMENT SHEETS

13. "The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box or meter or other enclosure with adequate space, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to be the point of entrance of the service conductors into the building"
14. "The words 'thermally protected' appearing on the nameplate of a motor-compressor indicate that the motor is provided with a thermal protector"
15. "So constructed or protected that exposure to the weather will not interfere with successful operation"
16. "Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors"
17. "An overcurrent protective device that contains a heater element in addition to and affecting a renewable fusible member which opens the circuit. It is not designed to interrupt short-circuit currents"
18. "The raceway that encloses the service-entrance conductors"
19. "Capable of being reached quickly for operation, renewal, or inspections, without requiring those whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc."
20. "Surrounded by a case, housing, fence, or wall which will prevent persons from accidentally contacting energized live parts"

Assignment Sheet #4

1.	25 (cannot be fused over 20A)	5.	30
2.	165	6.	25 (cannot be fused over 20A)
3.	195	7.	125
4.	50 (cannot be fused over 30A)	8.	55

Assignment Sheet #5

1.	9	6.	4
2.	6	7.	2
3.	1	8.	6
4.	11	9.	4
5.	2	10.	3

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #6

PART I

A. Article part A, *Code* section 250-1
   1. "Systems, circuits, and equipment required, permitted, or not permitted to be grounded"
   2. "Circuit conductor to be grounded on grounded systems"
   3. "Location of grounding connections"
   4. "Types and sizes of grounding and bonding conductors and electrodes"
   5. "Methods of grounding and bonding"
   6. "Conditions under which guards, isolation, or insulation may be substituted for grounding"

B. Article part B; *Code* section 250-6(a); True
C. Article part C; *Code* section 250-26(c); True
D. Provided; fault current; Article part G; *Code* section 250-70
E. Uninsulated; Article part G; *Code* section 250-73
F. Jumper; four exceptions; Article part G; *Code* section 250-74
G. Copper; Article part G; *Code* section 250-79(a)
H. Article part J; *Code* section 250-95; #8, #6, #3
I. Cases or frames; Article part L; *Code* section 250-122
J. Not; Article part K; *Code* section 250-113

PART II

A. True; *Code* section 336-3(a)
B. 6 feet; *Code* section 336-9, ref. to 333-12(a)
C. False; *Code* section 345-3(a), ref. to 250-91(b)
D. True; *Code* section 346-1(b) exception
E. True; *Code* section 346-7(b)
F. True; *Code* section 347-8, table
G. True; *Code* section 348-7
H. True; *Code* section 349-4
I. True; *Code* section 350-3, exception #3
J. True; *Code* section 364-2

PART III

A. True; *Code* section 430-7(a)(2)
B. Motor control circuit; *Code* section 430-71
C. False; *Code* section 430-110(b)
D. True; *Code* section 440-22(a)
E. False; *Code* section 445-5

ANSWERS TO ASSIGNMENT SHEETS

F. True; *Code* section 450-47
G. True; *Code* section 480-2
H. True; *Code* section 500-4
I. False; *Code* section 501-5(a)(1)

PART IV

A. Five; *Code* section 230-46
B. True; *Code* section 240-4
C. True; *Code* section 370-6(c)
D. Faceplate; *Code* section 370-15
E. True; Note 12 to tables 310-16 through 310-19
F. 333-12; *Code* section 336-9
G. One minute; *Code* section 460-6(a)
H. True; *Code* section 500-5
I. True; *Code* section 680-6(a)(3)

USING TRADE INFORMATION
UNIT VI

TEST

NAME ______________________________________ SCORE ________________

1. Match terms related to using trade information with their correct definitions. Definitions are continued on the following page.

_____a. Develops electrical equipment standards

_____b. Develops standards for electrical machinery and equipment

_____c. Develops and publishes fire and industrial safety standards

_____d. Develops standards for electrical equipment and supplies

_____e. Test equipment and list items for use in specified situations

_____f. Standards developed to provide for safe building construction practices

_____g. Intentionally grounded system or circuit conductor

_____h. Book containing electrical specifications endorsed by NFPA and ANSI; used for legal and regulatory purposes in the interest of life and property protection

_____i. Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

_____j. Conductor used to connect the grounding electrode to the equipment grounding conductor or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system

_____k. Connections between two or more portions of the equipment grounding conductors

_____l. Power, right, or authority to interpret the law (code)

_____m. Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

1. ANSI (American National Standards Institute)
2. ASA (American Standard Association)
3. Bonding
4. Bonding jumpers
5. Bonding jumper circuit
6. Bonding jumper equipment
7. Building code
8. Grounded
9. Grounded conductor
10. Grounding conductor
11. Grounding electrode conductor
12. Jurisdiction
13. Mandatory enforcement
14. NEC (National Electrical Code)
15. NEMA (National Electrical Manufacturers Association)
16. NFPA (National Fire Protection Association)
17. UL (Underwriters Laboratories)

TEST

______n. Governmental authority to demand compliance with the *National Electrical Code* requirements for electrical installations

______o. Conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

______p. Pieces of wire or other conductors that connect different metal parts

______q. Connected to earth or to some conducting body that serves in place of the earth

2. State the purpose of the National Electrical Code.

3. List factors that are not covered by the NEC.

   a. ______

   b. ______

   c. ______

4. State the intent of the NEC regarding mandatory enforcement.

5. Match *National Electrical Code* chapter numbers on the right with their correct areas of application.

______a. Communications systems

______b. Special equipment

______c. General application

______d. Tables and examples

______e. Special conditions

______f. Hazardous locations

1. Chapters 1 through 4
2. Chapter 5
3. Chapter 6
4. Chapter 7
5. Chapter 8
6. Chapter 9

TEST

6. Arrange in order the organizational components of *National Electrical Code* information. Write a "1" before the first step, a "2" before the second step, and so on.

    _____a. Numbered paragraphs

    _____b. Article

    _____c. Chapter

    _____d. Parts

    _____e. Numbered or lowercase lettered subparagraphs

7. Arrange in order the steps for finding information in the *National Electrical Code*. Write a "1" before the first step, a "2" before the second step, and so on.

    _____a. Turn to article and section as designated.

    _____b. Read all related areas and exceptions.

    _____c. Refer to index for appropriate area of code.

    _____d. Cross-reference if code refers to another article.

    _____e. Locate specified area in question.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

8. Use the National Electrical Code (NEC) index. (Assignment Sheet #1)

9. Use the National Electrical Code (NEC) introduction and first chapter. (Assignment Sheet #2)

10. Answer questions related to residential wiring practices using the NEC as a reference. (Assignment Sheet #3)

11. Locate allowable ampacities for various conductors using the NEC as a reference. (Assignment Sheet #4)

12. Interpret conduit fill tables using the NEC as a reference. (Assignment Sheet #5)

13. Find information in the NEC. (Assignment Sheet #6)

USING TRADE INFORMATION
UNIT VI

ANSWERS TO TEST

1. a. 15
   b. 2
   c. 16
   d. 1
   e. 17
   f. 7
   g. 9
   h. 14
   i. 3
   j. 11
   k. 6
   l. 12
   m. 5
   n. 13
   o. 10
   p. 4
   q. 8

2. Sets minimum standards for safeguarding persons and property from hazards arising from the use of electricity

3. a. Efficiency
   b. Convenience
   c. Good service

4. The code is intended to be suitable for mandatory enforcement by the governmental authority having jurisdiction. Mandatory rules are characterized by the word "SHALL".

5. a. 5
   b. 3
   c. 1
   d. 6
   e. 4
   f. 2

6. a. 4
   b. 2
   c. 1
   d. 3
   e. 5

7. a. 3
   b. 4
   c. 1
   d. 5
   e. 2

8.-13. Evaluated to the satisfaction of the instructor

BASIC EQUIPMENT
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and install electrical boxes and enclosures used in the electrical field. Competencies will be demonstrated by completing the assignment sheet, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to basic equipment with their correct definitions.
2. Identify classes of outlet boxes used in electrical wiring.
3. List information needed to calculate boxfill.
4. Match types of enclosures with their correct conditions for use.
5. State the purposes of controller enclosures.
6. Label types of devices commonly used in electrical wiring.
7. Label types of covers and plates used in electrical wiring.
8. Identify supports and anchors commonly used in electrical wiring.
9. Identify screws, bolts, and nuts commonly used in electrical wiring.
10. Identify classes of box mounting devices for steel structures.
11. Determine the correct number of conductors for boxfill. (Assignment Sheet #1)

OBJECTIVE SHEET

12. Demonstrate the ability to:

    a. Install outlet boxes on wood studs on a framed wall. (Job Sheet #1)

    b. Install outlet boxes on steel structures and rods using caddy clips. (Job Sheet #2)

    c. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes. (Job Sheet #3)

    d. Install masonry boxes in a block wall. (Job Sheet #4)

BASIC EQUIPMENT
UNIT VII

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Devise additional job sheets for applications based on the wiring method of the locality.
2. Discuss slang terms associated with basic equipment.
3. Show examples of outlet boxes and electrical devices to class.
4. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. Adams, James E. and Gordon Rockmaker. *Industrial Electricity Prinicíples and Practices*. Third Edition. New York: McGraw-Hill Book Co., 1985.

B. *National Electrical Code, 1987*. Quincy, MA: National Fire Protection Association, 1986.

C. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

D. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

SUGGESTED SUPPLEMENTAL MATERIAL

Catalogs

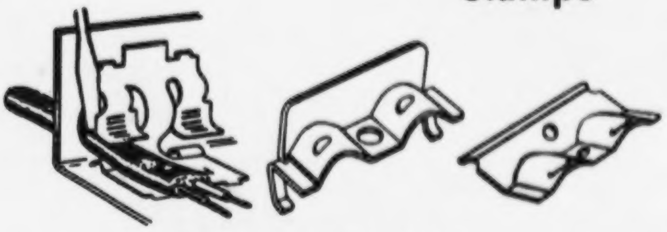
A. *Holub Catalog No. 23*, ITT Holub Industries, Sycamore, Illinois.

B. *Roco Steel Box Catalog No. B-774*, Roco Inc., South Bend, Indiana.

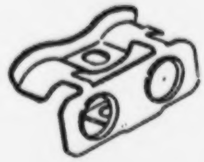
C. *Leviton Catalog D-100*, Leviton Manufacturing Co., Brooklyn, New York.

Box Design Features

Clamps

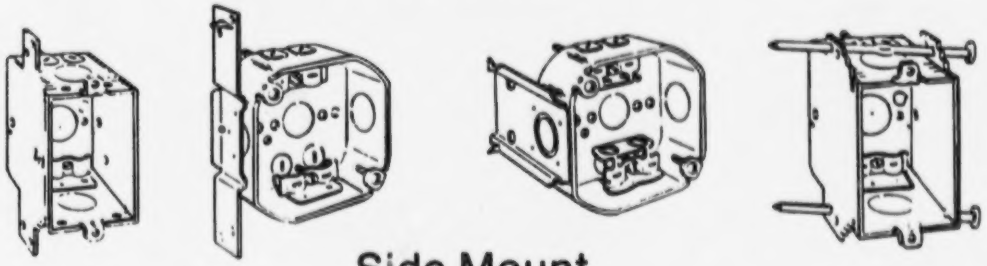


Nonmetallic
Cable Clamps

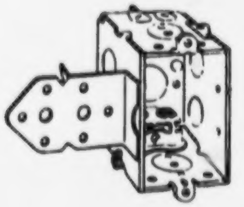


Metallic
Cable Clamp

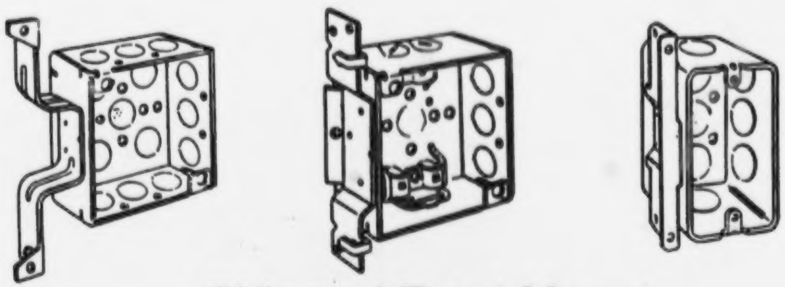
Brackets



Side Mount



Front
Mount

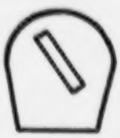


Side and Front Mount

Box Design Features
(Continued)

Box Openings

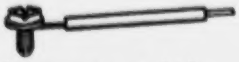
Knockout



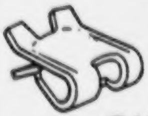
Pry-Out

Grounding Equipment

Screw

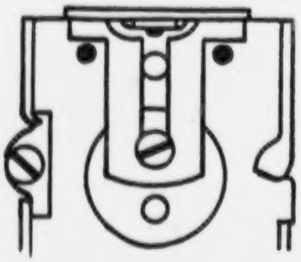


Screw with Pigtail

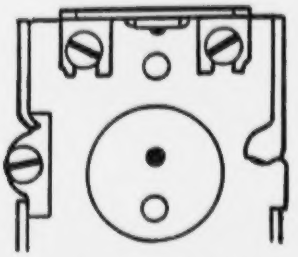


Clip

Plaster Ears



One-Screw Design



Two-Screw Design

BASIC EQUIPMENT
UNIT VII

INFORMATION SHEET

I. **Terms and definitions**

A. Boxfill — Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

B. Cabinet — Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

C. Disconnecting means — Device or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

D. Dustproof — So constructed or protected that dust will not interfere with successful operation

E. Dusttight — So constructed that dust will not enter the enclosing case

F. Explosionproof — Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

G. Joint Industry Conference (JIC) boxes — Boxes or enclosures made to Joint Industry Conference Standards for such uses as junction boxes and housing terminal blocks

H. Junction boxes — Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

I. Knockout (KO) — Partially cut out piece of metal or plastic that can be forced out when a hole is needed

J. NEMA enclosures — Electrical enclosures specifically designed to standards for use in specific locations and various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

K. Outlet boxes — Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

L. Rainproof — So constructed, protected, or treated as to prevent rain from interfering with successful operation

M. Raintight — So constructed or protected that exposure to a beating rain will not result in the entrance of water

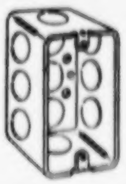
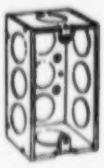
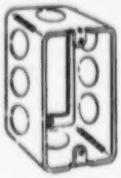
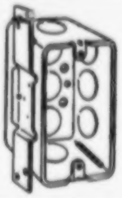
INFORMATION SHEET

II. Classes of outlet boxes used in electrical wiring (NEC Article 370)

A. Outlet boxes (device boxes)

(NOTE: Most boxes can be purchased in metal or in a nonmetallic composition such as fiber, plastic, nylon, or rubber.)

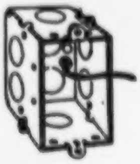
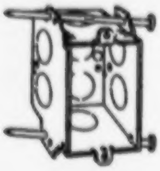
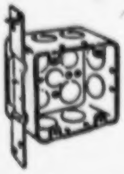
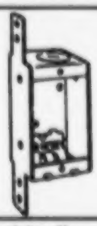
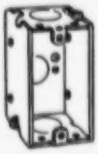
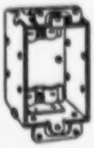
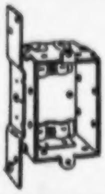
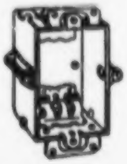
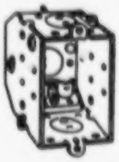
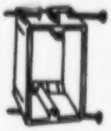
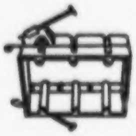
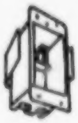
1. Handy boxes

One-Piece Molded Construction	One-Piece Welded Construction	Extension	Box with Bracket
			

INFORMATION SHEET

2. Switch boxes

(NOTE: Switch boxes are available in steel, plastic, and Bakelite.)

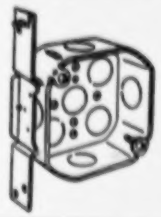
Gangable with Grounding Pigtail	Nail-On	Solid Two-Gang Bracket
		
Nongangable Bracket with Cable Clamps	**Gangable with Nail Holes**	**Gangable with Ears and Cable Clamps**
		
Gangable Bracket with Cable Clamps	**Box with Drywall Grips, Cable Clamps, and Ears**	**Beveled Corner with Clamps and Ears**
		
Single Gang Fiber Nail-Up	**Three-Gang Fiber Nail-Up**	**Single Gang Fiber Cut-In Box**
		

INFORMATION SHEET

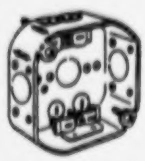
B. Octagon boxes

(NOTE: Octagon boxes, like switch boxes, can be either metallic or nonmetallic; like switch boxes, they can be purchased in many different depths.)

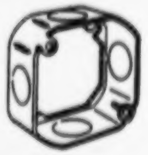
Box with Bracket



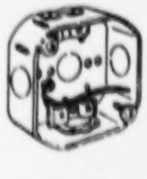
Box with Cable Clamps and Nail Holes



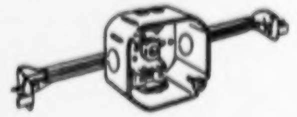
Extension



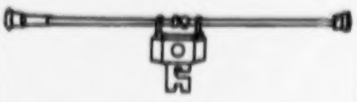
Box with Cable Clamps and Grounding Pigtail



Box with Bar Hanger and Cable Clamps



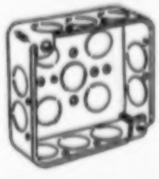
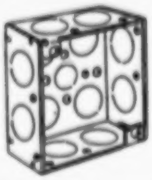
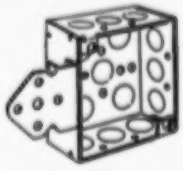
Fan Hanger Box

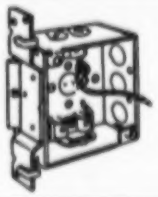
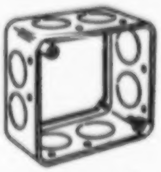


INFORMATION SHEET

C. Square boxes

(NOTE: Square boxes are used in conjunction with covers designed for special purposes.)

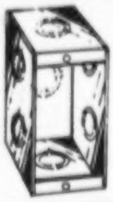
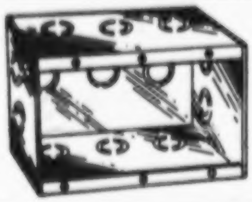
One-Piece Molded Construction	One-Piece Welded Construction	Box with Bracket
		

Box with Bracket, Cable Clamps, and Grounding Pigtail	Extension
	

D. Masonry boxes

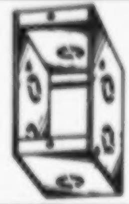
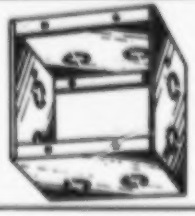
(NOTE: Masonry boxes have square corners that are easier to cut and save installation time. The boxes are deep so that conduit will position in the voids.)

1. Regular masonry boxes

Single-Gang	Three-Gang
	

INFORMATION SHEET

2. Masonry through-the-wall boxes

Single-Gang	Two-Gang
	

III. Information needed to calculate boxfill

A. Cubic inches of box

(NOTE: Multiplying width times height times depth gives cubic inches.)

B. Size of wire

C. Number of devices and grounds

IV. Types of enclosures and their conditions for use

A. General duty — For normal use in locations without excessive dust, moisture, or corrosive atmospheres

B. Dustproof — For use where dust could interfere with normal operation

EXAMPLES: Feed mill, cement plant

C. Weatherproof — For use where rain or dust could interfere with normal operation

EXAMPLE: Irrigation motor controller

D. Watertight — For use in wet locations

EXAMPLES: Milk plant, mines

E. Corrosionproof — For use in locations having corrosive atmospheres (NEC Article 300-6)

EXAMPLES: Galvanizing plant, fertilizer plant

F. Explosionproof — For use in hazardous locations (NEC Article 500)

EXAMPLES: Grain elevators, oil refineries, chemical plants

INFORMATION SHEET

V. **Purposes of controller enclosures**

A. Keeping boxes and enclosures clean

(NOTE: Relays and contactors should be cleaned periodically to ensure continued operation.)

B. Keeping boxes and enclosures dry

(NOTE: Moisture is one of the greatest enemies of electrical insulation. Moisture due to condensation may collect inside a sealed enclosure. Heaters are often used to correct this condition.)

C. Protecting boxes and enclosures from accidental contact

(CAUTION: Never bring metal or other objects into contact with live parts.)

D. Preventing injuries

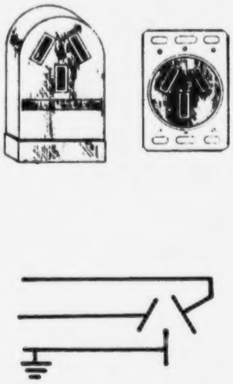
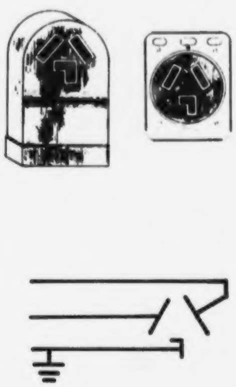
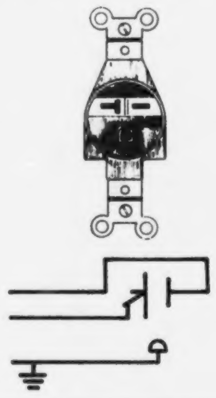
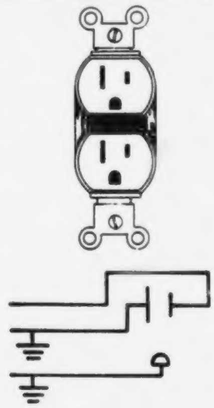
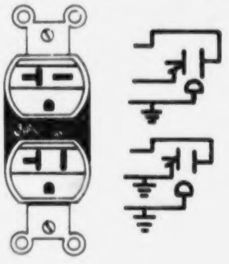
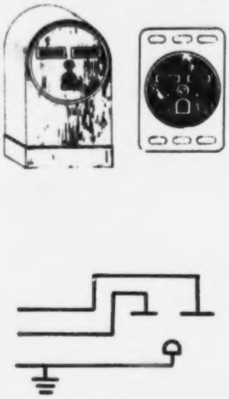
(CAUTION: To avoid personal injury, protective covers must be in place when system is in operation.)

INFORMATION SHEET

VI. Types of devices commonly used in electrical wiring

(NOTE: Manufacturers make different grades of devices. Price and quality vary with the grades. Specification grade is the most expensive. Before installing devices, check the grade requested in the job bid.)

A. Receptacles

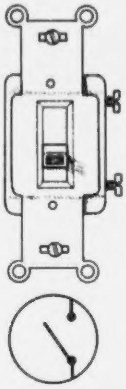
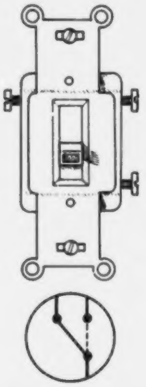
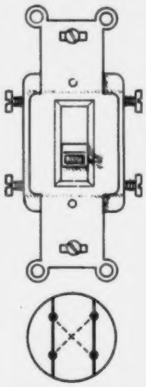
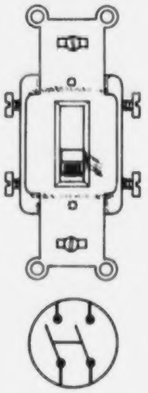
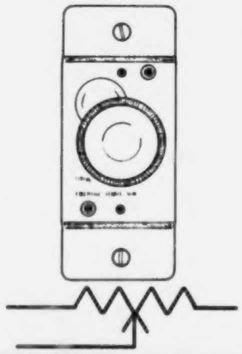
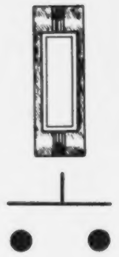
125/250 V, 50 A	125/250 V, 30 A	250 V, 20 A
		
Duplex Grounding 125 V, 15 A	Dual Voltage 125/250 V, 20 A	250 V, 30 A
		

(NOTE: NEC Articles 250-74, 410-58 and 501-12 deal with specific installation of receptacles.)

EXAMPLE: 410-58(a) grounding-type receptacles, cord connectors, and attachment plugs shall be provided with one fixed grounding pole in addition to the circuit poles.

INFORMATION SHEET

B. Switches

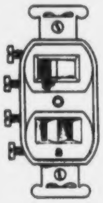
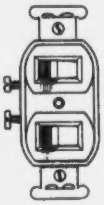
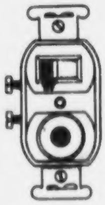
Single Pole	Three-Way	Four-Way
		
Double Pole	**Dimmer**	**Low-Voltage Push Button**
		

(NOTE: Article 380 of the NEC covers switches.)

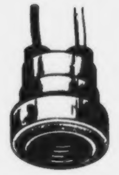
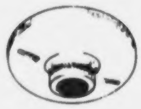
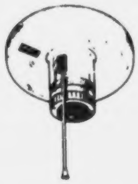
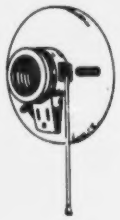
EXAMPLE: 380-2 three-way and four-way switches shall be wired that all switching is done only in the ungrounded circuit conductor. Where in metal enclosures, wiring between switches and outlets shall be run with both polarities in the same enclosure.

INFORMATION SHEET

C. Combination devices

Switch and Receptacle	Two Switches	Switch and Pilot Light
		

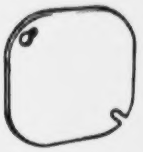
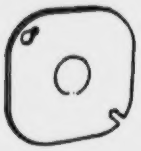
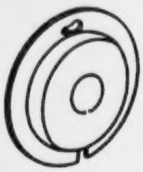
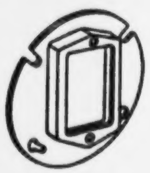
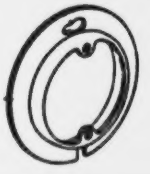
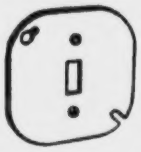
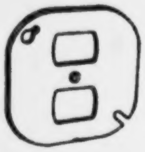
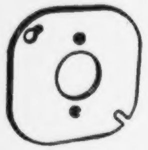
D. Sockets

Keyless Pigtail	Keyless Cover
	
Pull-Chain Cover	**Pull-Chain Cover with Grounding-Type Receptacle**
	

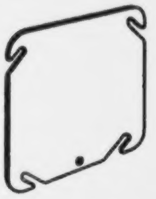
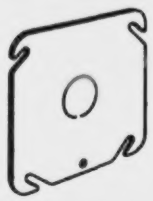
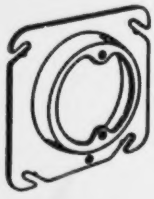
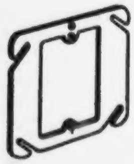
INFORMATION SHEET

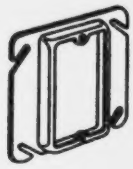
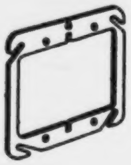
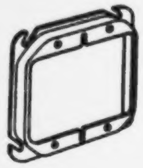
VII. Types of covers and plates used in electrical wiring

A. Round covers

Flat Blank	Flat Blank with Knockout	Raised with Knockout	Raised for Single Device
			
Raised Open	**Flat Toggle**	**Flat Duplex Receptacle**	**Flat Single Receptacle**
			

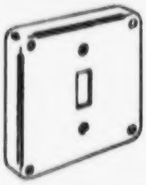
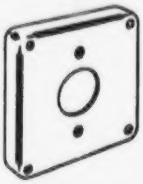
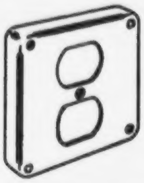
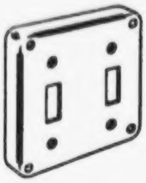
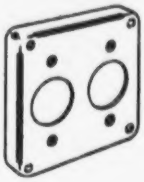
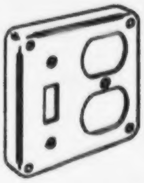
B. Square covers

Flat Blank	Flat Blank with Knockout	Raised Open	Flat for Single Device
			

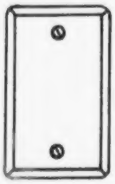
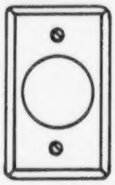
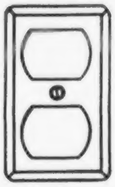
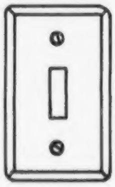
Raised for Single Device	Flat for Two Devices	Raised for Two Devices
		

INFORMATION SHEET

C. Exposed work raised square covers

Single Toggle	Single Receptacle	Duplex Receptacle
		
Two-Toggle	Two-Receptacle	Toggle and Duplex Receptacle
		

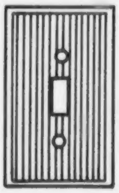
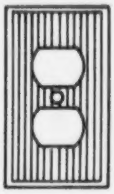
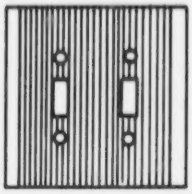
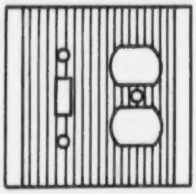
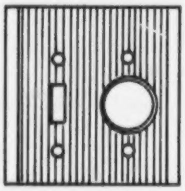
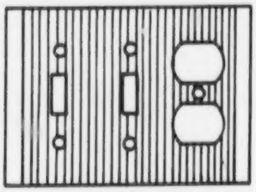
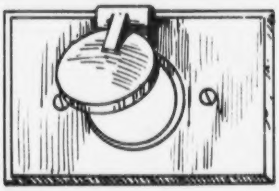
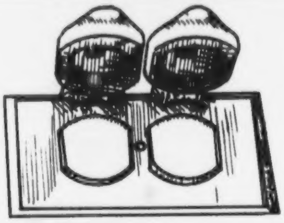
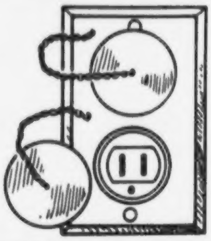
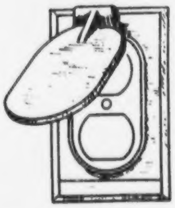
D. Handy box covers

Blank	Single Receptacle
	
Duplex Receptacle	Single Toggle
	

INFORMATION SHEET

E. Wall plates

(NOTE: These are usually available in plastic or metal, but also come in decorator types for interior walls which are often made from wood.)

<table>
<tr><th>Single Toggle</th><th>Duplex Receptacle</th><th>Two-Toggle</th><th>Single Toggle and Duplex Receptacle</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="2">Single Toggle and Single Receptacle</th><th colspan="2">Two-Toggle and Duplex Receptacle</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th colspan="2">Weatherproof Single Receptacle</th><th colspan="2">Weatherproof Duplex Receptacle (Horizontal)</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th colspan="2">Weatherproof Duplex Receptacle with Screw Covers</th><th colspan="2">Weatherproof Duplex Receptacle (Vertical)</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
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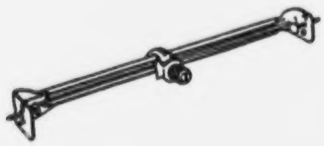
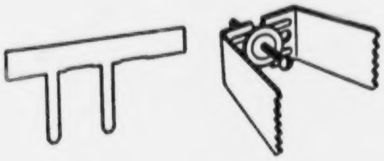
INFORMATION SHEET

VIII. Supports and anchors commonly used in electrical wiring

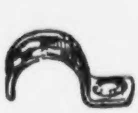
A. Bar hanger



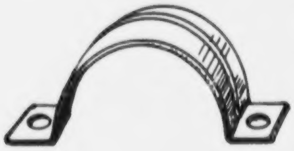
B. Switch-box supports



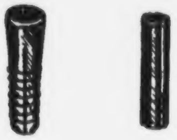
C. One-hole strap



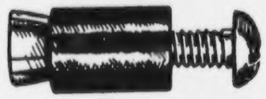
D. Two-hole strap



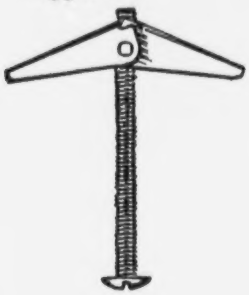
E. Plastic anchors



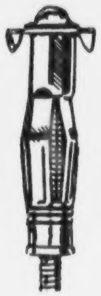
F. Lead anchor



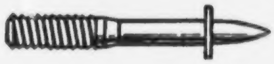
G. Toggle bolt



H. Molly bolt



I. Drive stud

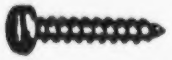


INFORMATION SHEET

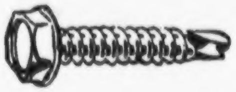
IX. Screws, bolts, and nuts commonly used in electrical wiring

A. Screws

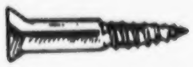
1. Sheet metal screw



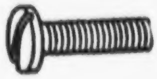
2. Self-drilling screw



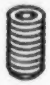
3. Wood screw



4. Machine screw

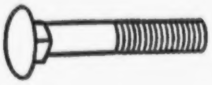


5. Setscrew

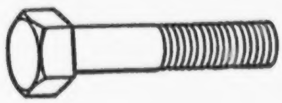


B. Bolts

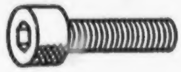
1. Carriage bolt



2. Hex-head bolt



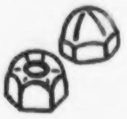
3. Hex-socket-head bolt



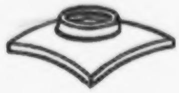
INFORMATION SHEET

C. Nuts

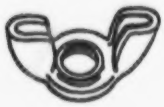
1. Acorn nut



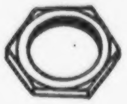
2. Spring nut



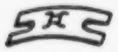
3. Wing nut



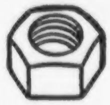
4. Fixture nut



5. Single-thread nut



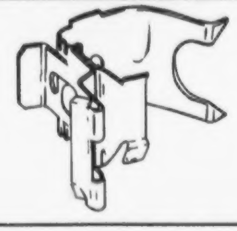
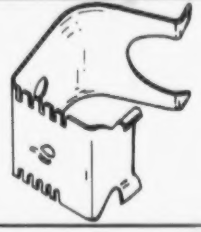
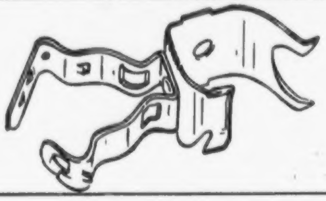
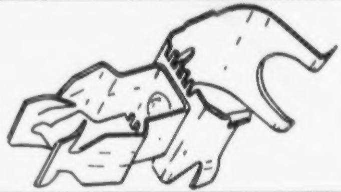
6. Plain hex nut



X. Classes of box-mounting devices for steel structures

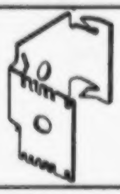
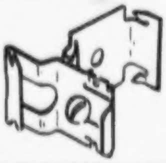
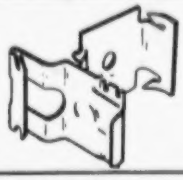
A. Metal stud clips for switch boxes

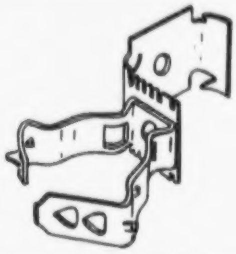
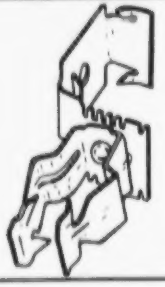
(NOTE: Some types of metal stud supports may require extra screws to secure them to studs.)

Riveted for Dry Wall, with Screw Adjustable 1/4" to 3/4"	**1/4"-20 Thread Impression to Metal Stud**
	
1/2" to 1" Conduit to Metal Stud	**1/2" to 1" Conduit to Metal Stud**
	

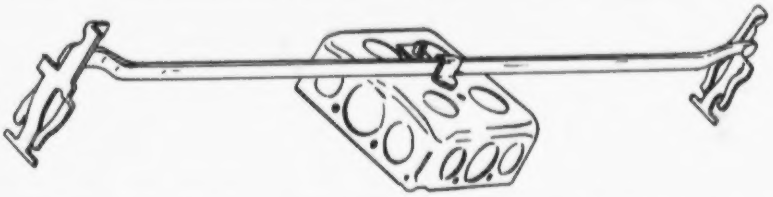
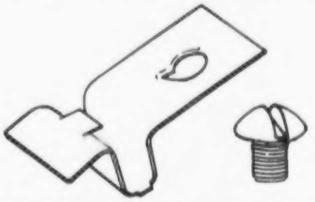
INFORMATION SHEET

B. MF clips for switch boxes (metal stud fasteners)

1/4"-20 Thread Impression to Metal Stud	**With Screw Adjustable 1/4" through 3/4"**	**Riveted for Flush Wall or 1/4" to 3/4" Dry Wall**
		

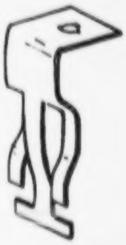
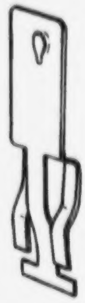
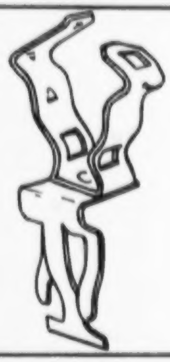
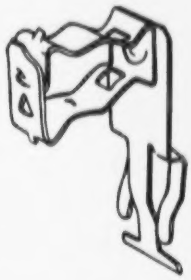
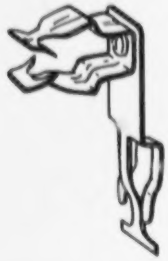
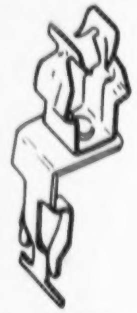
Condult on BX to Metal Stud	**1/2" to 1" Conduit to Metal Stud**
	

C. Acoustical tee-bar electrical box hanger and mounting clip

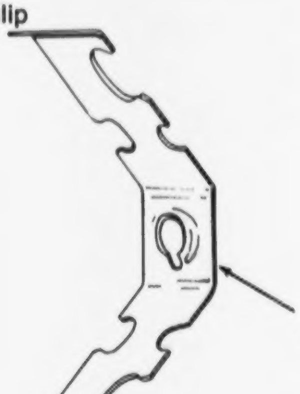
Acoustical "Tee-Bar" Electrical Box Hanger

Mounting Clip


INFORMATION SHEET

D. Acoustical tee-bar clips

Top-Mount, with ¼"-20 Thread Impression	Side-Mount, with ¼"-20 Thread Impression	Top-Mounted Conduit Clip for ⅜" or ½" to ¾" Conduit
		
With Side-Mounted Conduit Clip for ⅜" or ½" to ¾" Conduit	**With Side-Mounted Conduit Clip for ½", ¾" or 1" Conduit**	**With Top-Mounted Conduit Clip for ½" or ¾" Conduit**
		

E. Conduit box clip



BASIC EQUIPMENT
UNIT VII

ASSIGNMENT SHEET #1 — DETERMINE THE CORRECT NUMBER OF CONDUCTORS FOR BOXFILL

NAME ______________________ SCORE ____________

The electrical worker must be able to choose a box of correct size and then determine the number of conductors permitted according to the *National Electrical Code*, Article 370-6.

Directions: Determine the correct number of conductors for boxfill for the problems below. To find boxfill, subtract one conductor per device and one conductor per one or more grounds from the maximum allowed number of conductors.

(NOTE: Assume 1 ground wire for each problem.)

EXAMPLE: 4" × 2 1/8" square box, two devices, #12 wire

1. Referring to box dimensions and wire size,locate the maximum number of conductors on chart in Article 370-6 (maximum number = 13).
2. Subtract one conductor for each device (13 − 2 = 11).
3. Subtract one conductor for ground (11 − 1 = 10).
4. Answer equals boxfill (boxfill = 10 conductors).

A. 4" × 2 1/8", no device, round box, cable clamp, #12 wire

Boxfill = ______________ conductors

B. 3 3/4" × 2" × 3 1/2", one device, masonry box, #12 wire

Boxfill = ______________ conductors

ASSIGNMENT SHEET #1

C. 3" × 2" × 1 1/2", one device, #10 wire

Boxfill = ____________________ conductors

D. 4" × 2 1/8" × 1 7/8", one device, #10 wire

Boxfill = ____________________ conductors

E. 4 11/16" × 1 1/2", two device, square box, #12 wire

Boxfill = ____________________ conductors

F. 4" × 1 1/4", round box, #12 wire

Boxfill = ____________________ conductors

G. 3" × 2" × 2 1/2", no device, #10 wire

Boxfill = ____________________ conductors

ASSIGNMENT SHEET #1

H. 3" × 2" × 3 1/2", no device, #10 wire

Boxfill = ____________________ conductors

I. 4 × 2 1/8" × 1 1/2", no device, #12 wire

Boxfill = ____________________ conductors

J. 4" × 1 1/4", two devices, square box, #12 wire

Boxfill = ____________________ conductors

BASIC EQUIPMENT
UNIT VII

ANSWERS TO ASSIGNMENT SHEET #1

A. 7

B. 7

C. 1

D. 3

E. 10

F. 4

G. 4

H. 6

I. 3

J. 5

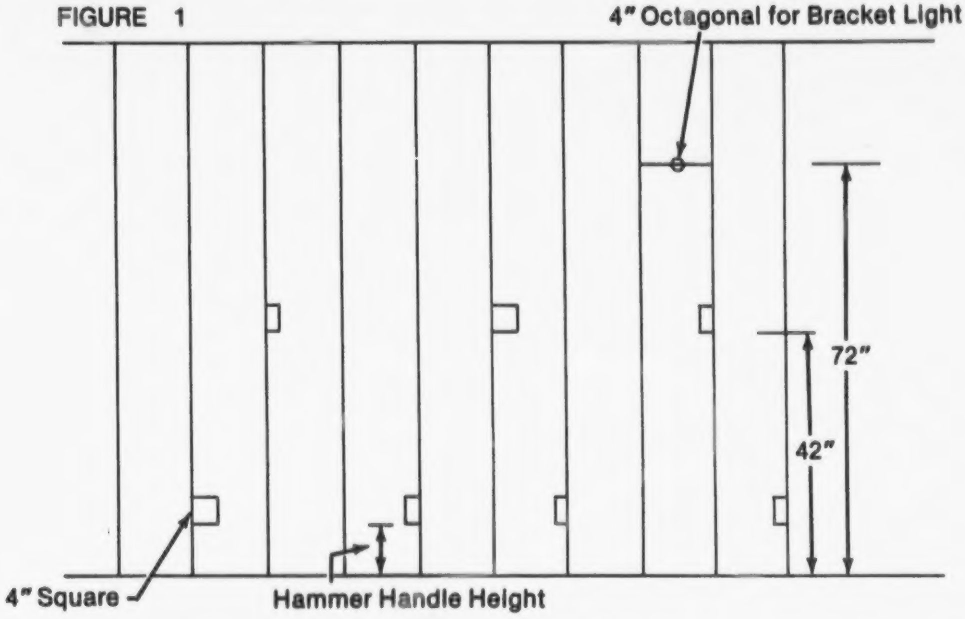
BASIC EQUIPMENT
UNIT VII

JOB SHEET #1 — INSTALL OUTLET BOXES ON WOOD STUDS ON A FRAMED WALL

A. Equipment and materials needed

1. Pouch tools, including hammer and tape
2. Construction blueprint showing locations and other necessary information for box installation (Figure 1)

FIGURE 1


4" Octagonal for Bracket Light
72"
42"
4" Square
Hammer Handle Height

3. 8-foot section of framed wall with 2" × 4" studs
4. Five outlet boxes (plastic)
5. Two 4-inch square boxes
6. Two plaster rings
7. #8 mounting nails
8. 4-inch octagon box
9. One expandable hanger bar

JOB SHEET #1

B. Procedure

1. View blueprint for installation information to determine location of boxes.

   (NOTE: Mount boxes to allow for 5/8-inch Sheetrock.)

2. Lay out job by marking studs where boxes are to be installed.

3. Place boxes on floor along wall where each is to be installed.

4. Measure heights, and mark studs for mounting boxes.

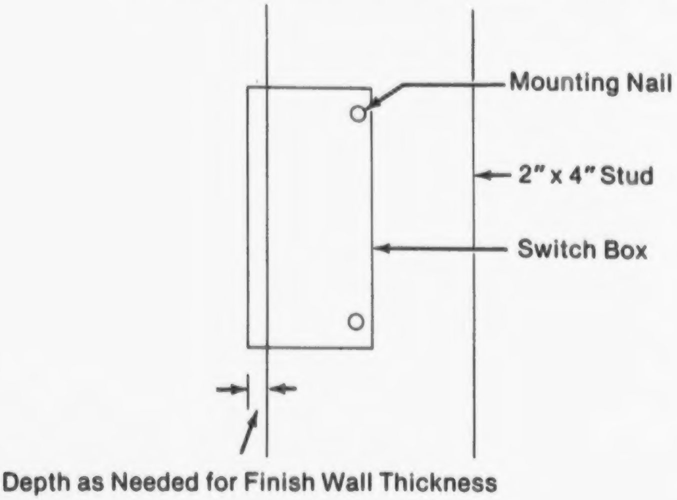
   (NOTE: A quick, accurate method for measuring for box installation is to cut a piece of conduit, lathe, or other similar material to proper length from floor or floor plate to bottom of box. Boxes can be held on top of the measuring device and fastened to stud. This will prevent reading a rule for locating each box. A method often used in industry for height location of receptacle boxes is to set a hammer on the floor and position the box on top of the handle. The receptacle box can be fastened to the stud at that height.)

5. Mount electrical boxes to studs at the locations and heights marked, with front edge of boxes parallel to face of stud and extended 1/2 inch to allow for 5/8-inch Sheetrock. (Figure 2)

   (NOTE: Four-inch square boxes are usually mounted with #8 or roofing nails, and switch boxes are usually mounted with #16 nails.)

FIGURE 2

Switch Box Mounted on a 2-Inch by 4-Inch Wall Stud



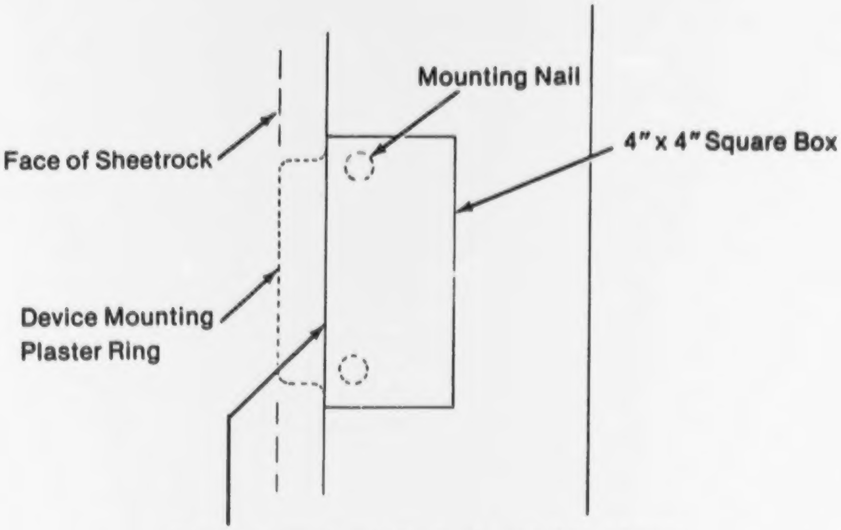
JOB SHEET #1

6. Mount 4-inch square boxes to studs at the height and location as marked with front edge of box flush with face of stud. (Figure 3)

   (NOTE: Set four-inch square boxes 1/2 inch lower than switch boxes, device screws inside.)

   FIGURE 3

   4" × 4" Box Mounted on 2" × 4" Stud


Mounting Nail
Face of Sheetrock
4" x 4" Square Box
Device Mounting Plaster Ring

Front of box should be flush with 2" x 4" stud.

JOB SHEET #1

7. Install octagonal outlet box for wall bracket light between two studs at location and height marked.

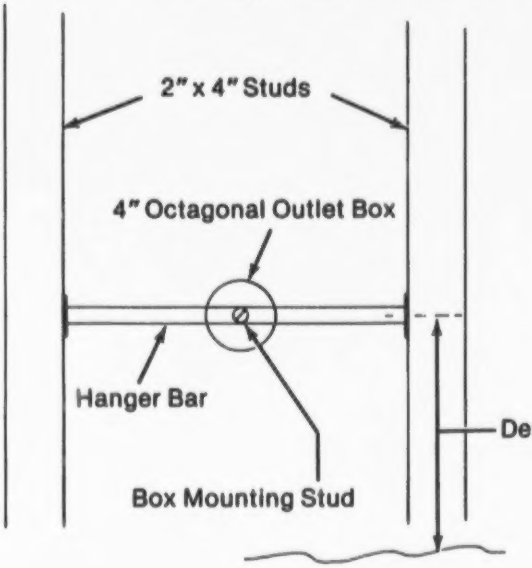
   a. Spread expandable hanger bar to proper length to properly fit between studs.

   b. Attach hanger bar to studs. (Figure 4)

   (NOTE: Hanger bars are usually fastened to studs with #8 nails.)

FIGURE 4

4" Octagonal Box Mounted on Hanger Bar


2" x 4" Studs
4" Octagonal Outlet Box
Hanger Bar
Designated Height
Box Mounting Stud

   c. Attach octagonal box to hanger-bar stud.

   (NOTE: Have instructor evaluate project.)

8. Carefully dismantle equipment and store in proper place; clean work area.

BASIC EQUIPMENT
UNIT VII

JOB SHEET #2 — INSTALL OUTLET BOXES ON STEEL STRUCTURES AND RODS USING CADDY CLIPS

A. Equipment and materials needed

1. Stove bolt, 1/4 inch by 1/2 inch
2. 3-foot piece of 1/2-inch EMT
3. 4-inch square outlet box, Raco #255 or equivalent
4. 1/2-inch EMT connector
5. Two 3-foot pieces of 1/4-inch rod
6. Two rod-hanger clamps, Caddy Catalog #708-2-4 or equivalent
7. Two conduit box clips, Caddy Catalog #4-1-2-4 or equivalent
8. Pouch tools

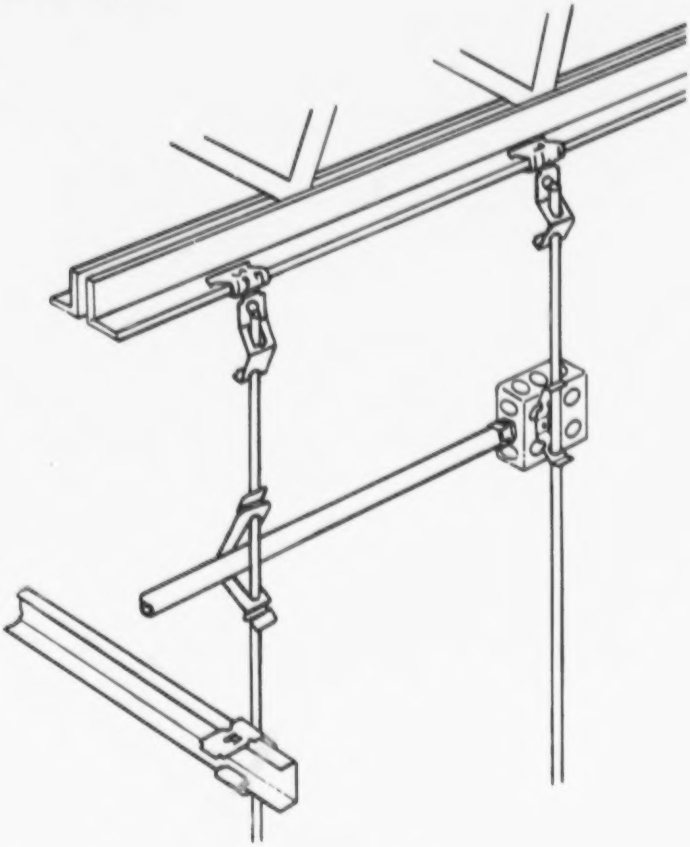
B. Procedure

1. Install two 1/4-inch rods in rod-hanger clamps.
2. Mount two rod-hanger clamps on suspended angle iron approximately 24 inches apart.

JOB SHEET #2

3. Install ½-inch EMT in 4-inch square box. (Figure 1)

FIGURE 1

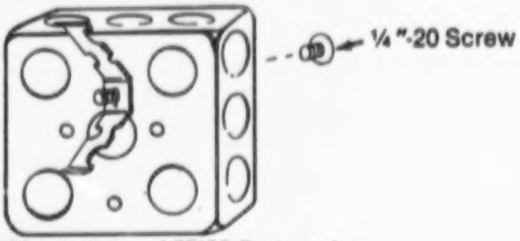


Used with permission of ERICO Products, Inc.

JOB SHEET #2

4. Fasten rod-hanger clip to square box. (Figure 2)

FIGURE 2

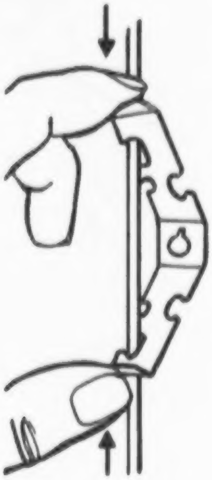


Used with permission of ERICO Products, Inc.

5. Mount box and EMT to the two ¼-inch rods. (See Figure 2)

6. Adjust to proper height. (Figure 3)

FIGURE 3



Used with permission of ERICO Products, Inc.

(NOTE: Have instructor evaluate your project.)

7. Carefully dismantle your equipment and store in the proper place; clean work area.

BASIC EQUIPMENT
UNIT VII

JOB SHEET #3 — INSTALL OUTLET BOXES ON STEEL STUDS USING CADDY METAL CLIPS FOR SWITCH BOXES

A. Equipment and materials needed

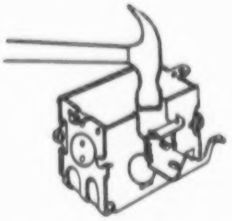
1. Pouch tools
2. 8-foot section of steel-stud wall
3. Three electrical boxes, Raco #560 or equivalent
4. 4-inch square electrical box, Raco #211 or equivalent
5. Handy box, Raco #660 or equivalent
6. Metal stud clip, Caddy #MSB-625 or equivalent
7. Four MF clips for switch boxes, Caddy #MF-625 or equivalent

B. Procedure

(NOTE: Boxes may be mounted at nondesignated places since intent of this job sheet is to acquaint students with box mounting methods when working with steel-stud walls.)

1. Mount metal stud clip to switch box. (Figure 1)

FIGURE 1



Used with permission of ERICO Products, Inc.

JOB SHEET #3

2. Mount box and clip to steel stud. (Figures 2 and 3)

FIGURE 2

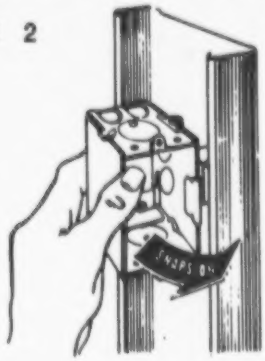


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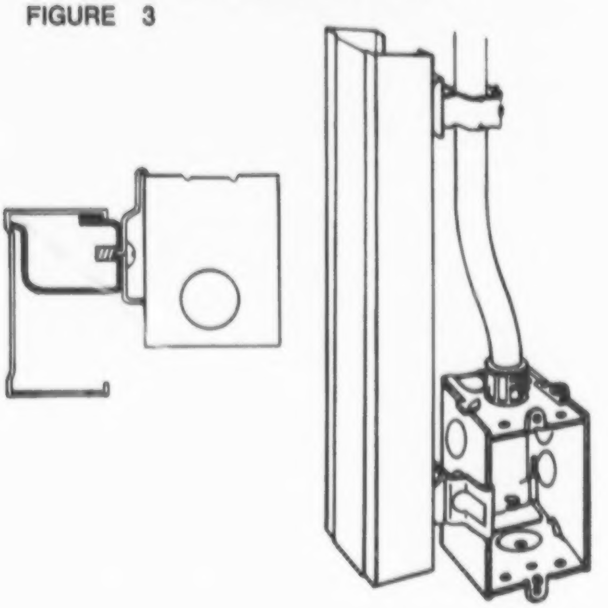
FIGURE 3



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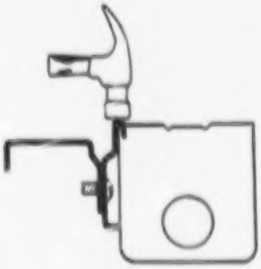
JOB SHEET #3

3. Mount one MF clip on each of the other boxes. (Figure 4)

FIGURE 4



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4. Mount clips and boxes to metal studs. (Figures 5 and 6)

FIGURE 5

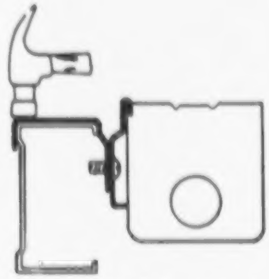

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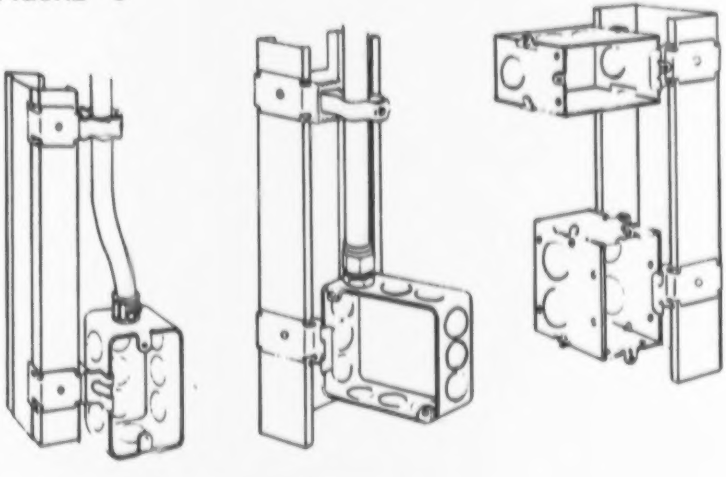
FIGURE 6



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JOB SHEET #3

(NOTE: Have instructor evaluate your work.)

5. Carefully dismantle your equipment and store in the proper place; clean work area.

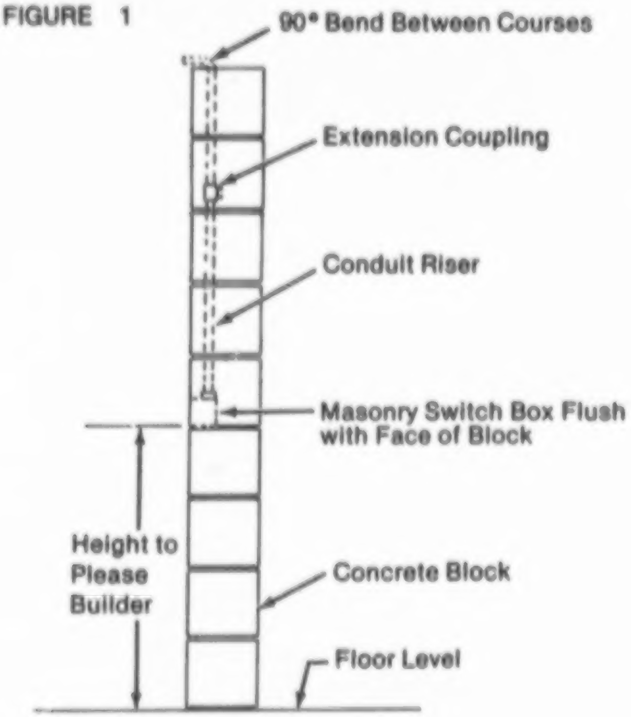
BASIC EQUIPMENT
UNIT VII

JOB SHEET #4 — INSTALL MASONRY BOXES IN A BLOCK WALL

A. Equipment and materials needed

1. Pouch tools
2. Hacksaw
3. Two masonry switch boxes, Raco #695 or equivalent
4. Two masonry two-gang boxes, Raco #696 or equivalent
5. 20 feet of ½-inch EMT
6. Four ½-inch EMT setscrew connectors
7. Four ½-inch EMT setscrew couplings
8. Condult bender
9. Blueprint (Figure 1)

FIGURE 1


90° Bend Between Courses
Extension Coupling
Conduit Riser
Masonry Switch Box Flush with Face of Block
Height to Please Builder
Concrete Block
Floor Level

JOB SHEET #4

B. Procedure

(NOTE: This job must be done in cooperation with the masonry instructor because the electrical components are to be installed as the block wall is constructed.)

1. Open ½-inch knockout hole nearest to the back of box so that EMT will be in the hollow of the cement blocks.

   (NOTE: Masonry boxes generally have concentric ½-inch and ¾-inch knockout punchings; exercise care to break out only the ½-inch part.)

2. Cut eight pieces of ½-inch EMT, approximately 30 inches long.

   (NOTE: Cut all eight pieces exactly the same length.)

3. Install ½-inch EMT connectors in each of the four masonry box knockout holes.

   (NOTE: If during knockout removal, the ¾-inch punching breaks out instead of the ½-inch punching, see your instructor. You will need two ¾-inch by ½-inch reducing washers for each ¾-inch hole to properly install ½—inch EMT.)

4. Install a 40-inch piece of EMT in each connector.

   (NOTE: The person laying the blocks must install each block down over the vertical conduit.)

5. Deliver the made-up boxes to the block layer.

   (NOTE: The electrician and the block layer must work together to be sure that the boxes are installed in the proper locations, and correctly installed with the EMT extending upward in the wall. See Figure 1)

6. When the block wall reaches desired height, install the masonry boxes with conduit extending upward.

7. Supervise the installation of the next layers of blocks until only a short portion of the conduit is visible above the wall.

   (NOTE: The block mason must raise the blocks above the height of the conduit, and then lower the next blocks over the conduit so that it extends upward through the hollow of the blocks.)

8. Install 30-inch pieces of conduit equipped with couplings to increase the height for next layers of blocks.

   (NOTE: The conduit is extended upward 2 or 3 feet at a time as the height of the wall increases.)

JOB SHEET #4

9. Make a 90-degree bend in the conduit when the wall and conduit reach required height.

   (NOTE: A 90-degree bend will allow the conduit to stick out of the wall between courses. This will prevent having to cut into the blocks.)

   (NOTE: Have the instructor evaluate your work.)

10. Dismantle equipment and store in the proper place; clean work area.

BASIC EQUIPMENT
UNIT VII

PRACTICAL TEST
JOB SHEET #1 — INSTALL OUTLET BOXES ON WOOD STUDS ON A FRAMED WALL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Marked out studs properly.	______	______
3. Laid out boxes properly.	______	______
4. Set at correct heights.	______	______
5. Set for 5/8 inch Sheetrock.	______	______
6. Mounted boxes securely.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Proper layout and marking	4	3	2	1
Proper heights	4	3	2	1
Proper setout (depth)	4	3	2	1
Workmanship	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

BASIC EQUIPMENT
UNIT VII

PRACTICAL TEST
JOB SHEET #2 — INSTALL OUTLET BOXES ON STEEL STRUCTURES AND RODS USING CADDY CLIPS

STUDENT'S NAME ______________________ DATE ________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Installed rod hanger clamps correctly.	______	______
3. Installed EMT and box properly (level).	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Rods plumb	4	3	2	1
Boxes secure	4	3	2	1
Conduit level	4	3	2	1
Workmanship	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

BASIC EQUIPMENT
UNIT VII

PRACTICAL TEST
JOB SHEET #3 — INSTALL OUTLET BOXES ON STEEL STUDS USING CADDY METAL CLIPS FOR SWITCH BOXES

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Attached clips to boxes properly.	______	______
3. Attached clips to studs properly.	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Boxes at proper height				
	4	3	2	1
Boxes secure				
	4	3	2	1
Workmanship				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

BASIC EQUIPMENT
UNIT VII

PRACTICAL TEST
JOB SHEET #4 — INSTALL MASONRY BOXES IN A BLOCK WALL

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cut EMT to proper lengths.	______	______
3. Installed connectors correctly.	______	______
4. Installed couplings properly.	______	______
5. Bent 90° properly.	______	______
6. Installed 30 inch sections of EMT properly.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Cut EMT to 30-inch lengths	4	3	2	1
90° bend true	4	3	2	1
Workmanship	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

BASIC EQUIPMENT
UNIT VII

TEST

NAME ______________________________ SCORE ____________

1. Match the terms on the right with their correct definitions. Definitions are continued on the following page.

______a. Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

______b. So constructed, protected, or treated as to prevent rain from interfering with successful operation

______c. So constructed that dust will not enter the enclosing case

______d. So constructed or protected that exposure to a beating rain will not result in the entrance of water

______e. Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

______f. Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

______g. Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

______h. Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

______i. So constructed or protected that dust will not interfere with successful operation

______j. Boxes or enclosures made to set standards for such uses as junction boxes and housing terminal blocks

1. Boxfill
2. Cabinet
3. Disconnecting means
4. Dustproof
5. Dusttight
6. Explosion-proof
7. Joint Industry Conference (JIC) boxes
8. Junction boxes
9. Knockout (KO)
10. NEMA enclosures
11. Outlet boxes
12. Rainproof
13. Raintight

TEST

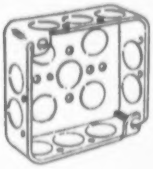
______k. Electrical enclosures specifically designed to standards for use in specific locations and for various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

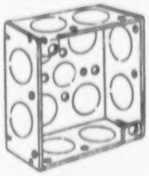
______l. Device or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

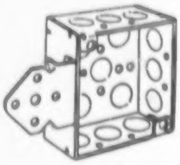
______m. Partially cut out piece of metal or plastic that can be forced out when a hole is needed

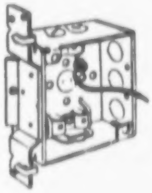
2. Identify the following classes of outlet boxes used in electrical wiring. Write the correct names in the blanks.

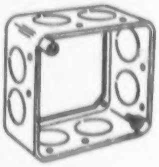
Octagon boxes
Regular masonry boxes
Handy boxes
Switch boxes
Masonry through-the-wall boxes
Square boxes





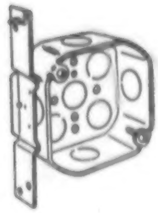


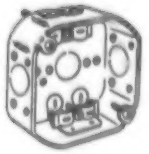


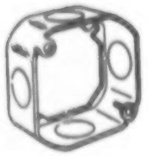


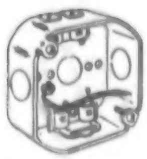
a. ______________________________

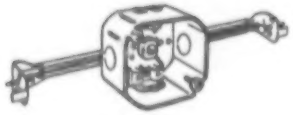
TEST







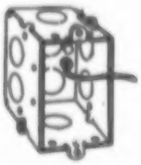
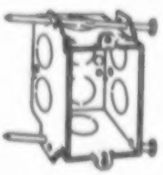
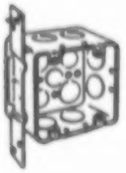
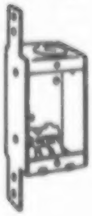
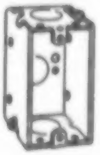
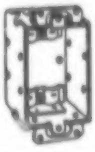
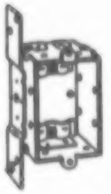
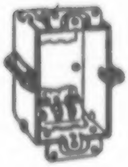
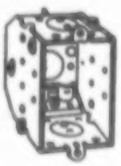




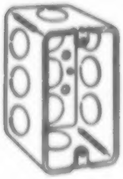
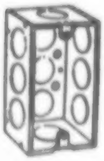
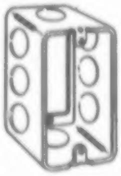
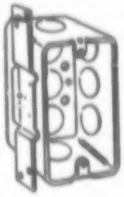
b. ______________________________

TEST

c. Outlet boxes (device boxes)

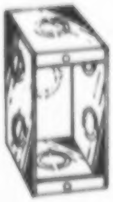
1) ____

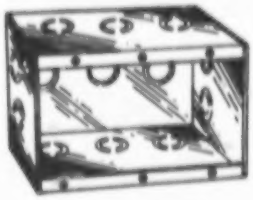





2) ____

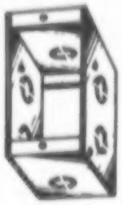
TEST

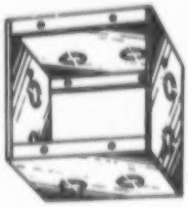
d. Masonry boxes





1) ______________________________





2) ______________________________

3. List information needed to calculate boxfill.

a. ______________________________

b. ______________________________

c. ______________________________

4. Match the types of enclosures on the right with their correct conditions for use.

______a. For use where rain or dust could interfere with normal operation

______b. For use in hazardous locations

______c. For normal use in locations without excessive dust, moisture, or corrosive atmospheres

______d. For use in locations having corrosive atmospheres

______e. For use where dust could interfere with normal operation

______f. For use in wet locations

1. Weatherproof
2. General duty
3. Corrosionproof
4. Explosionproof
5. Dustproof
6. Watertight

TEST

5. State the purposes of controller enclosures.

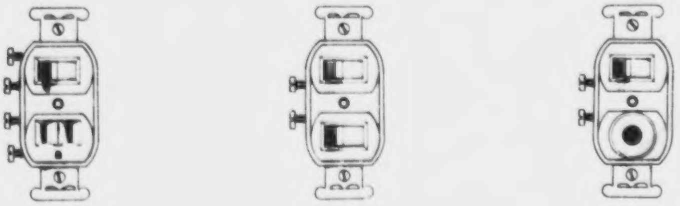
   a. ______________________________

   b. ______________________________

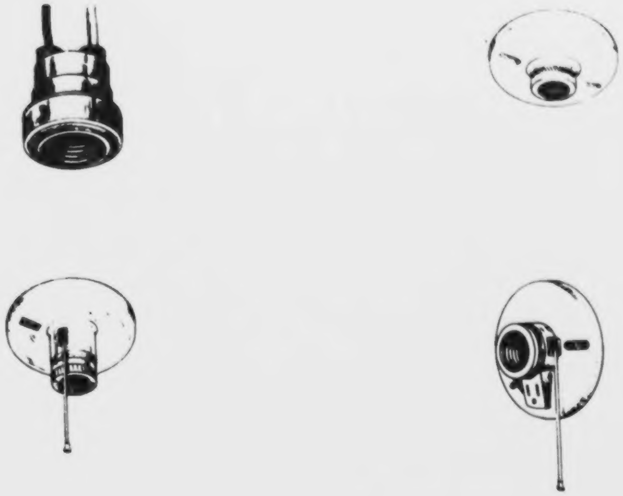
   c. ______________________________

   d. ______________________________

6. Label the following types of devices commonly used in electrical wiring.

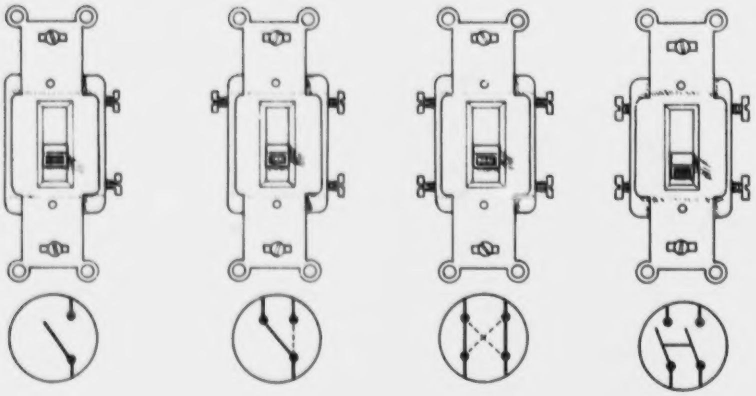


   a. ______________________________

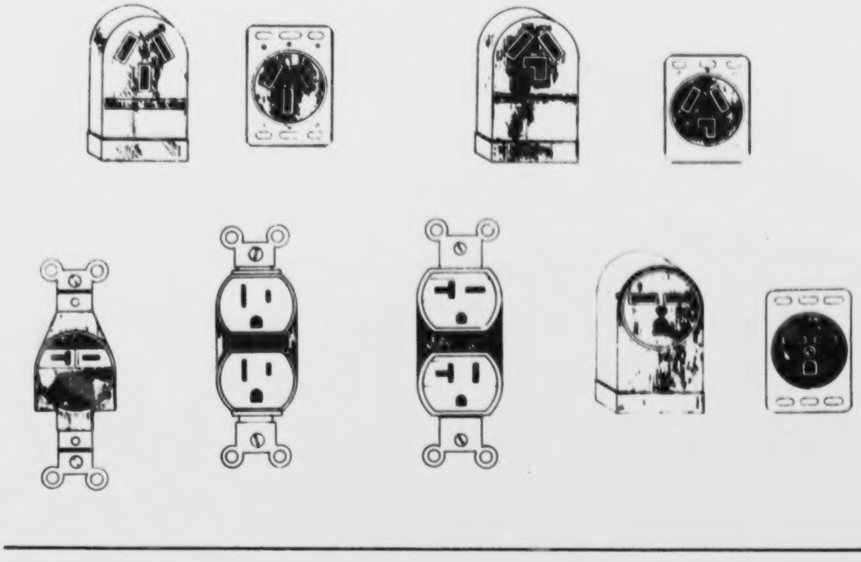


   b. ______________________________

TEST



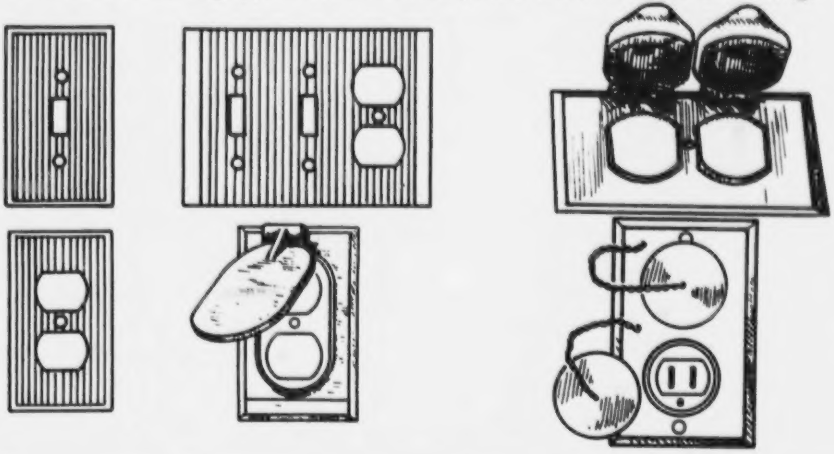
c. ______________________________



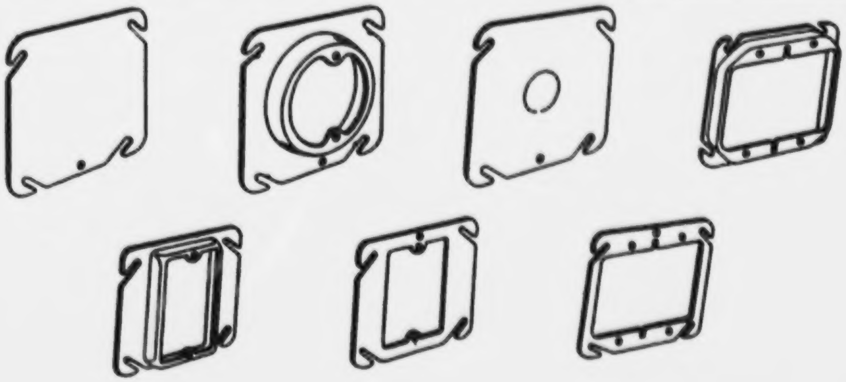
d. ______________________________

TEST

7. Label the following types of covers and plates used in electrical wiring.

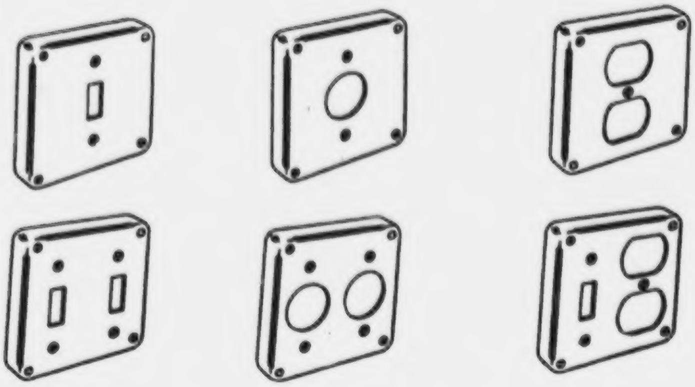


a. ____

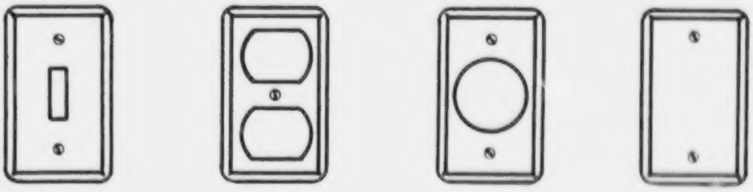


b. ____

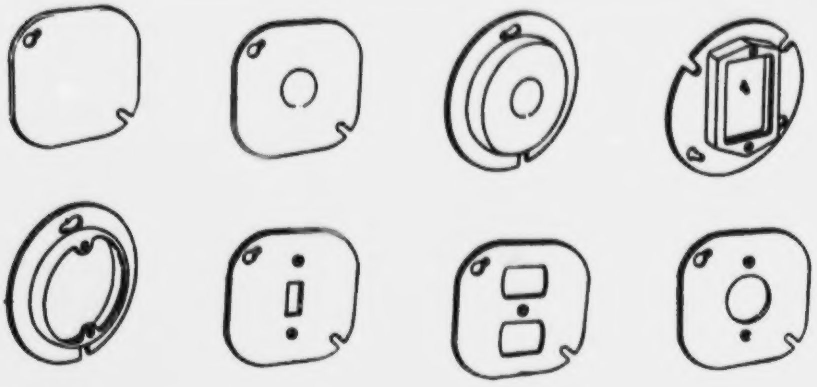
TEST



c. ______________________________



d. ______________________________

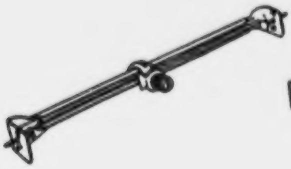


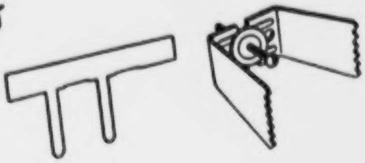
e. ______________________________

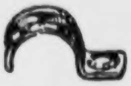
TEST

8. Identify the following supports and anchors commonly used in electrical wiring. Write the correct names in the blanks.

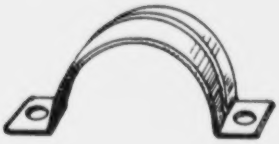
Molly bolt
Switch-box supports
Two-hole strap
Bar hanger
Drive stud
One-hole strap
Lead anchor
Plastic anchors
Toggle bolt

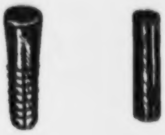


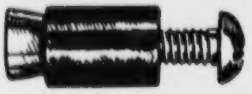




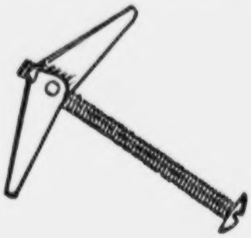
a. ____________________ b. ____________________ c. ____________________

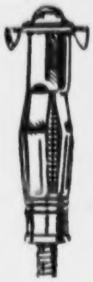


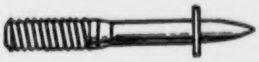




d. ____________________ e. ____________________ f. ____________________





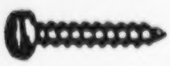


g. ____________________ h. ____________________ i. ____________________

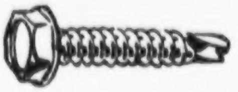
TEST

9. Identify the following screws, bolts, and nuts commonly used in electrical wiring. Write the correct names in the blanks.

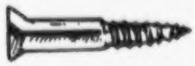
Setscrew
Wood screw
Spring nut
Wing nut
Machine screw
Single-thread nut
Sheet metal screw
Self-drilling screw
Hex-head bolt
Plain hex nut
Fixture nut
Hex-socket-head bolt
Carriage bolt
Acorn nut



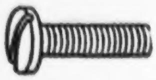
a. ______________________



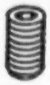
b. ______________________



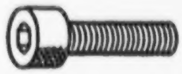
c. ______________________



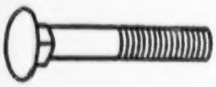
d. ______________________



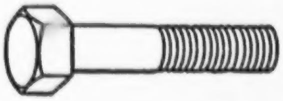
e. ______________________



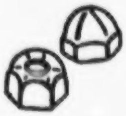
f. ______________________



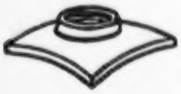
g. ______________________



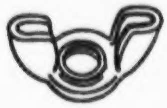
h. ______________________



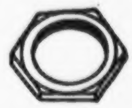
i. ______________________



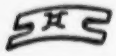
j. ______________________



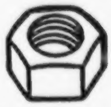
k. ______________________



l. ______________________



m. ______________________________

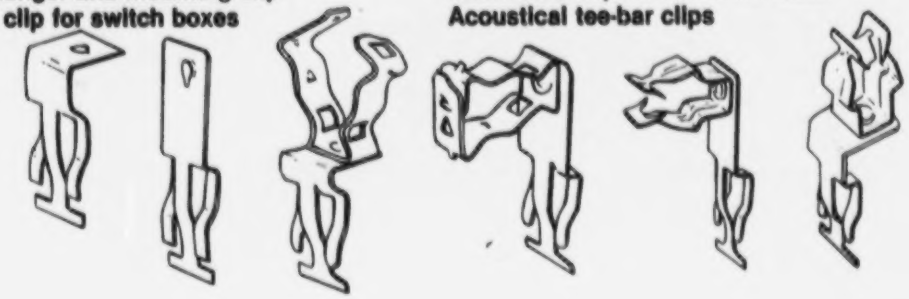


n. ______________________________

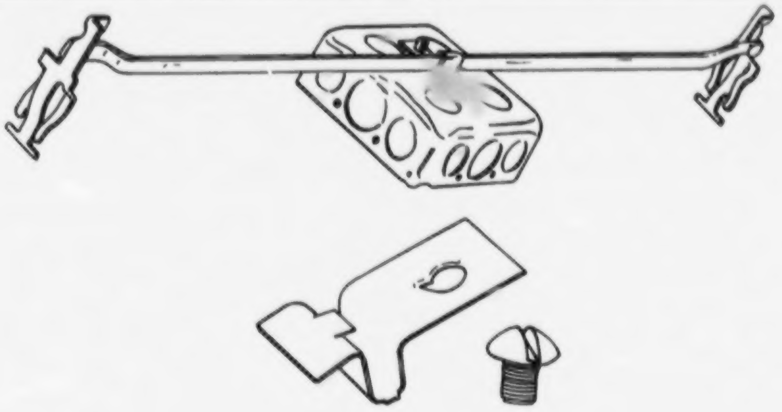
TEST

10. Identify the following classes of box-mounting devices for steel structures. Write the correct names in the blanks.

Acoustical tee-bar electrical box Hanger and mounting clip
MF clip for switch boxes
Conduit box clip
Metal stud clips for switch boxes
Acoustical tee-bar clips

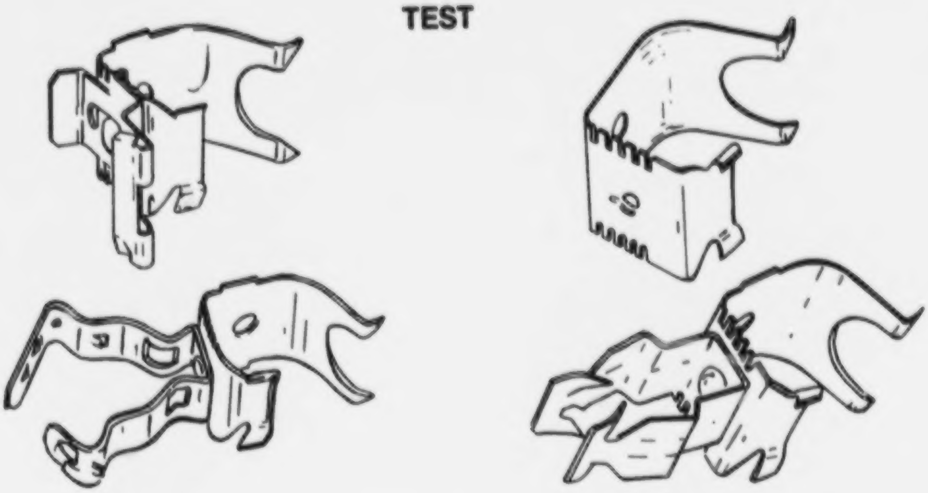


a. ______________________________

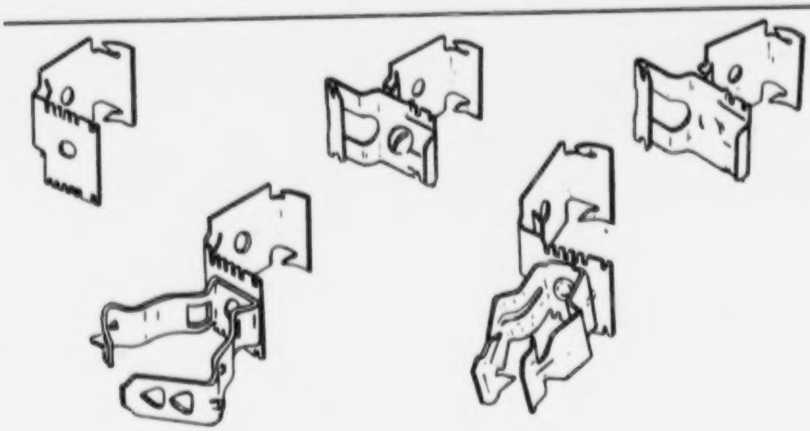


b. ______________________________

TEST

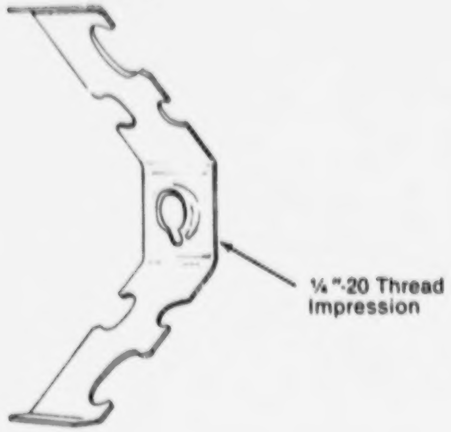


c. ______________________________



d. ______________________________

TEST



e. ______________________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

11. Determine the correct number of conductors for boxfill. (Assignment Sheet #1)

12. Demonstrate the ability to:

    a. Install outlet boxes on wood studs on a framed wall. (Job Sheet #1)

    b. Install outlet boxes on steel structures and rods using caddy clips. (Job Sheet #2)

    c. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes. (Job Sheet #3)

    d. Install masonry boxes in a block wall. (Job Sheet #4)

BASIC EQUIPMENT
UNIT VII

ANSWERS TO TEST

1. a. 8
   b. 12
   c. 5
   d. 13
   e. 6
   f. 11
   g. 2
   h. 1
   i. 4
   j. 7
   k. 10
   l. 3
   m. 9

2. a. Square boxes
   b. Octagon boxes
   c. Outlet boxes (device boxes)
      1) Switch boxes
      2) Handy boxes
   d. Masonry boxes
      1) Regular masonry boxes
      2) Masonry through-the-wall boxes

3. a. Cubic inches of box
   b. Size of wire
   c. Number of devices and grounds

4. a. 1
   b. 4
   c. 2
   d. 3
   e. 5
   f. 6

5. a. Keeping boxes and enclosures clean
   b. Keeping boxes and enclosures dry
   c. Protecting boxes and enclosures from accidental contact
   d. Preventing injuries

6. a. Combination devices
   b. Sockets
   c. Switches
   d. Receptacles

7. a. Wall plates
   b. Square covers
   c. Exposed work raised square covers
   d. Handy box covers
   e. Round covers

ANSWERS TO TEST

8. a. Bar hanger
   b. Switch box supports
   c. One-hole strap
   d. Two-hole strap
   e. Plastic anchors
   f. Lead anchor
   g. Toggle bolt
   h. Molly bolt
   i. Drive stud

9. a. Sheet metal screw
   b. Self-drilling screw
   c. Wood screw
   d. Machine screw
   e. Setscrew
   f. Hex-socket-head bolt
   g. Carriage bolt
   h. Hex-head bolt
   i. Acorn nut
   j. Spring nut
   k. Wing nut
   l. Fixture nut
   m. Single-thread nut
   n. Plain hex nut

10. a. Acoustical tee-bar clips
    b. Acoustical tee-bar electrical box hanger and mounting clip
    c. Metal stud clips for switch boxes
    d. MF clips for switch boxes
    e. Conduit box clip

11. Evaluated to the satisfaction of the instructor

12. Performance skills evaluated to the satisfaction of the instructor

BASIC THEORY
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify electrical schematic symbols and apply Ohm's law formulas. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to basic theory with their correct definitions.
2. Select true statements concerning the principles of electron flow.
3. Complete statements concerning basic sources of generation.
4. Complete statements concerning the distribution of electricity.
5. Match electrical schematic symbols with their correct names.
6. Distinguish between diagrams and schematics.
7. Complete a list of letters and their terms.
8. State Ohm's law.
9. Draw Ohm's law in wheel expression.
10. List three uses of Ohm's law.
11. State the formulas from Ohm's law.
12. State Ohm's law for power.

OBJECTIVE SHEET

13. Draw Ohm's law for power in wheel expression.

14. List three uses of Ohm's law for power.

15. State the formulas from Ohm's law for power.

16. Draw a diagram of the power distribution supplying your school shop. (Assignment Sheet #1)

17. Solve problems for an unknown voltage. (Assignment Sheet #2)

18. Solve problems for an unknown amperage. (Assignment Sheet #3)

19. Solve problems for unknown resistances and wattages. (Assignment Sheet #4)

BASIC THEORY
UNIT VIII

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

1. Provide students with enough practice concerning basic theory to meet local employment needs.
2. Have representatives from a local power company discuss the distribution of electricity in your community. Coordinate this with the completion of Assignment Sheet #1.
3. Have students construct a model or draw diagrams of an atom showing its makeup.
4. Show or give examples of basic sources of generation.
5. Relate Ohm's law to series and parallel circuits.
6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *Basic Electricity Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

B. Miller, Rex. *Industrial Electricity*. Peoria, IL: Bennett Publishing Company, 1982.

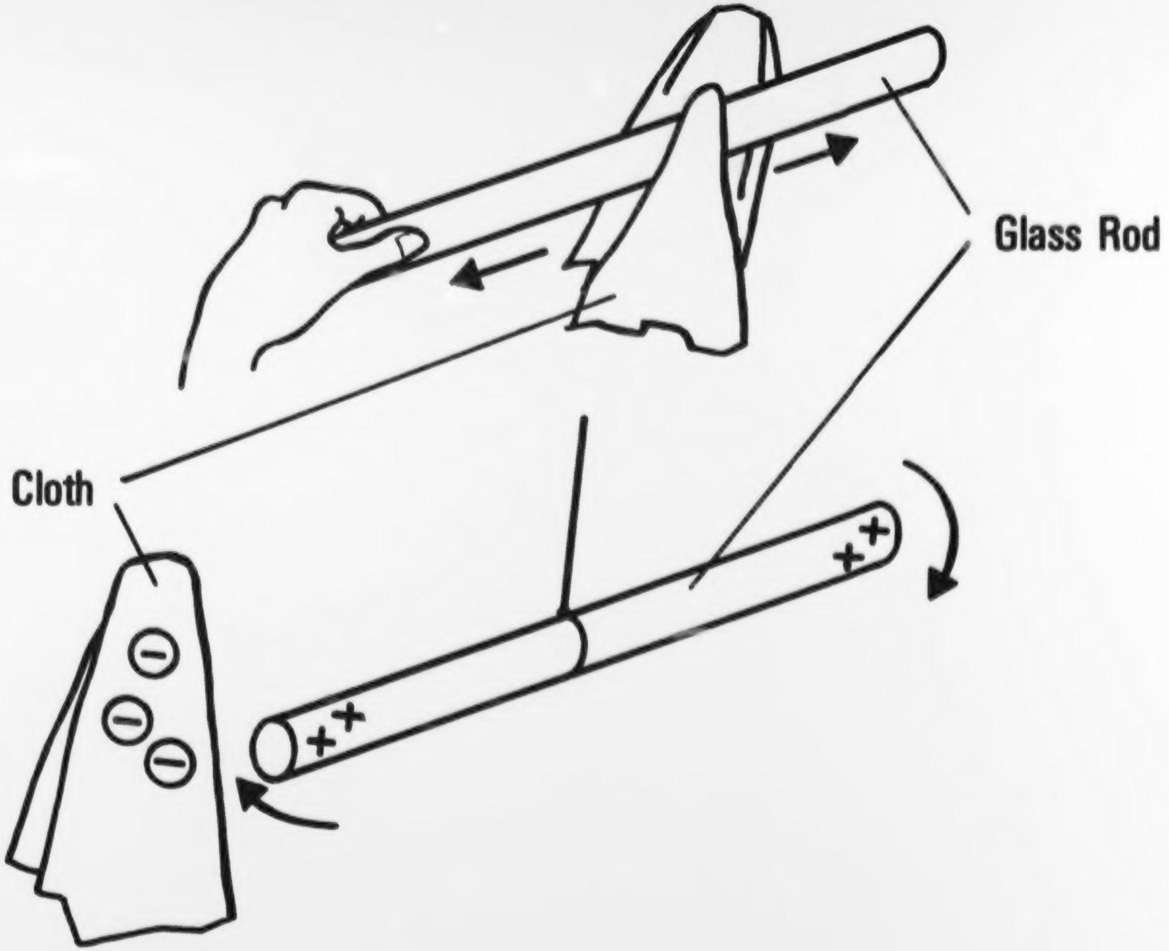
C. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

D. Turner, J. Howard. *Understanding Electricity and Electrical Terms*. Athens, GA: American Association for Vocational Instructional Materials, 1974.

SUGGESTED SUPPLEMENTAL MATERIAL

Film — *Basic Electricity Review*. NUS Training Corporation, 1350 Piccard Drive, Rockville, MD, 20850.

Friction Produces Electricity

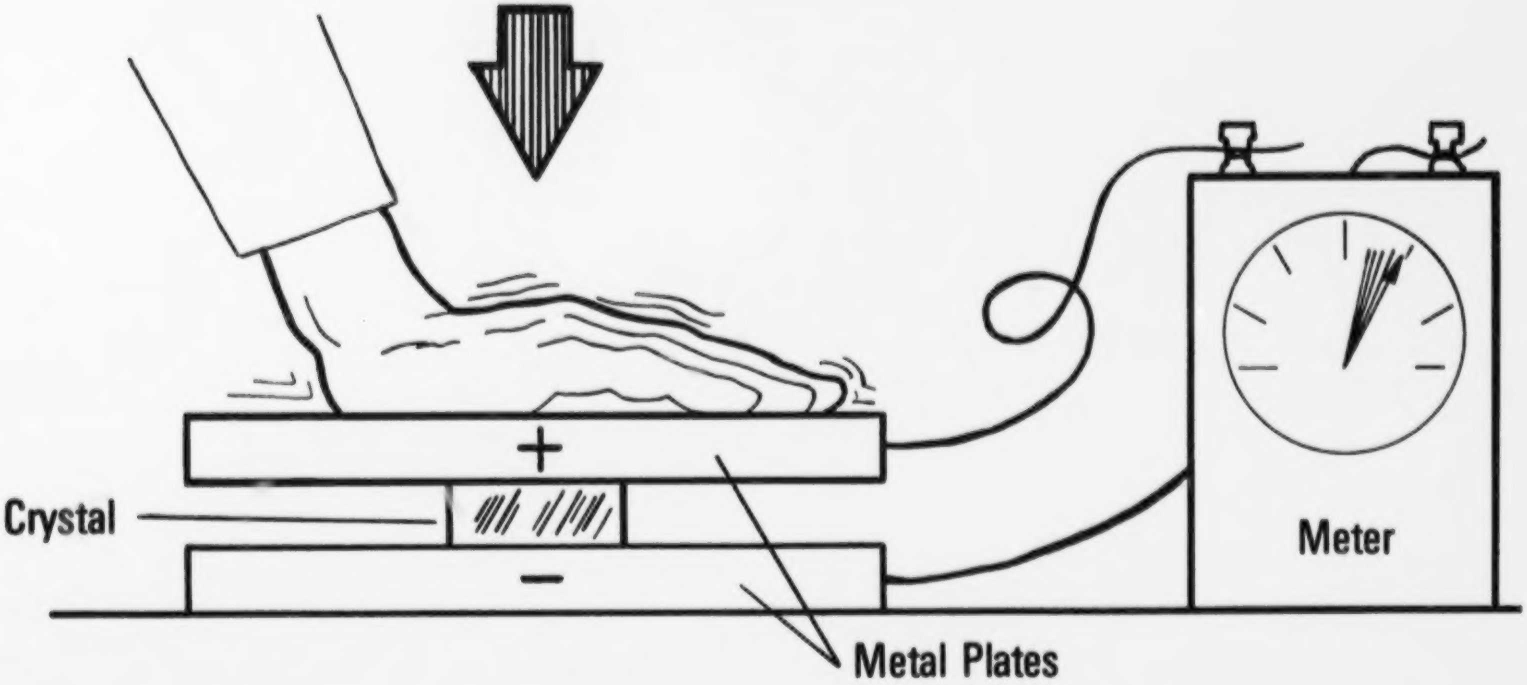

Glass Rod
Silk Cloth
+
+
+
+
−
−
−

TM 1
Objective III

BW-419

Pressure Produces Electricity

(Piezoelectric Effect)

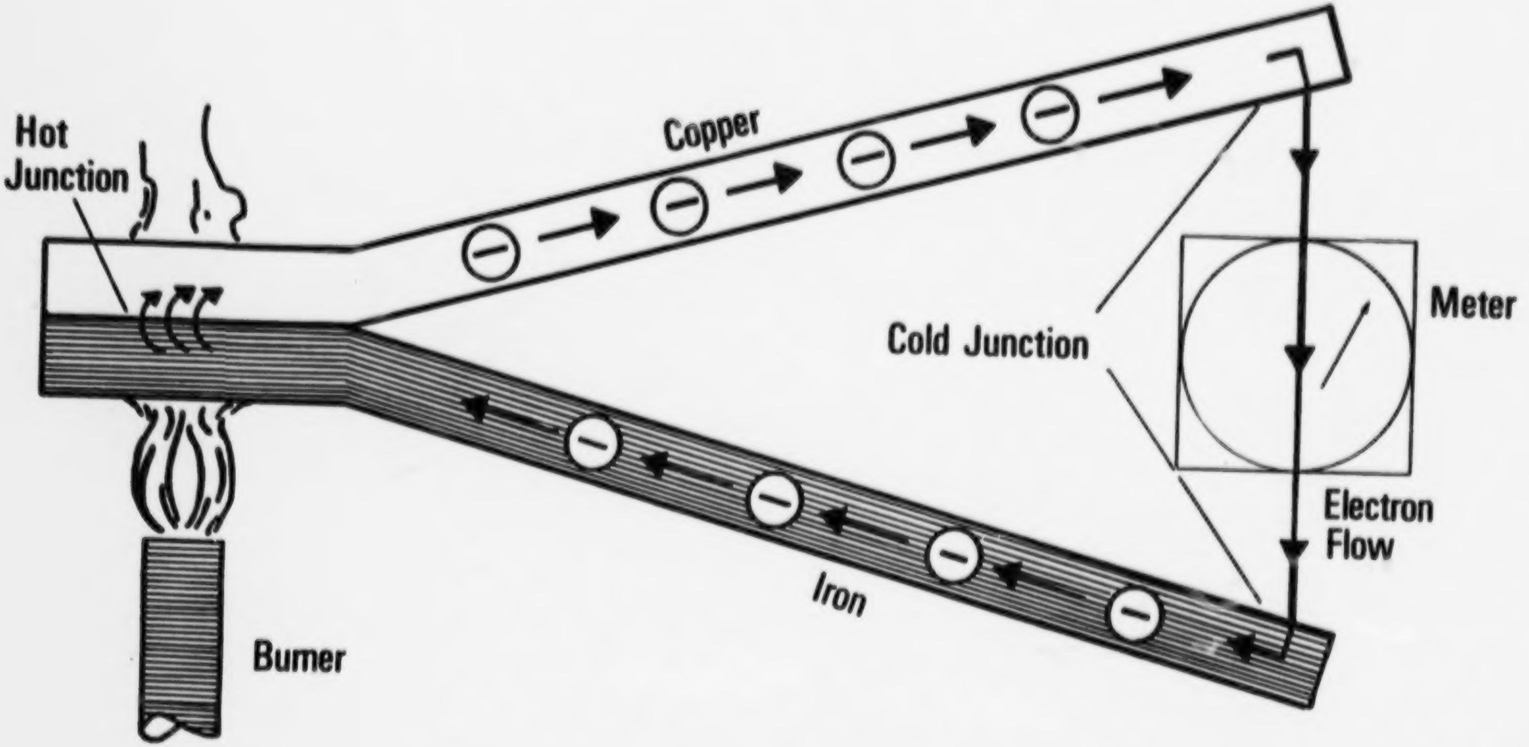

+
Crystal
−
Meter
Metal Plates

TM 2
Objective III

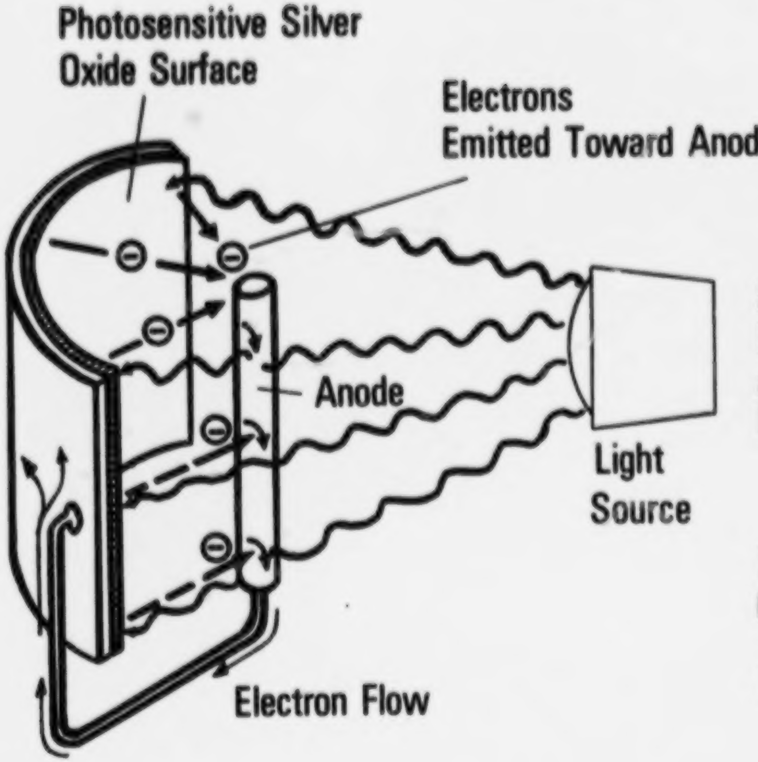
BW-421

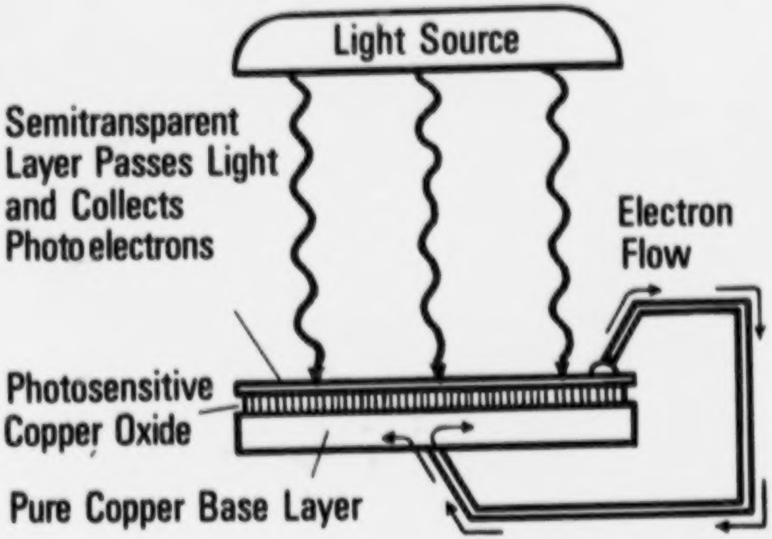
Heat Produces Electricity

(Thermocouple)

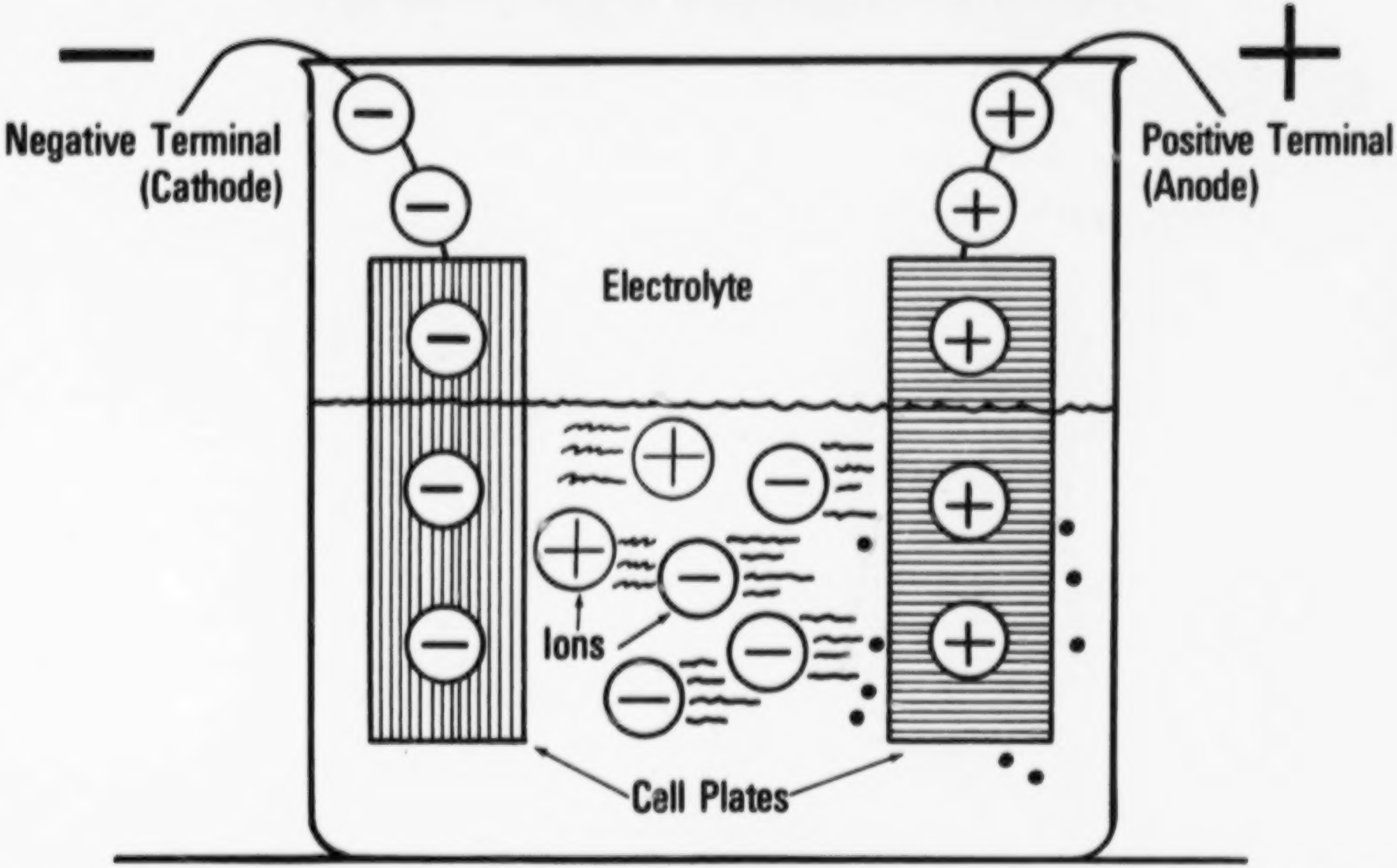

Hot Junction
Copper
Cold Junction
Meter
Electron Flow
Iron
Burner

Light Produces Electricity


Photosensitive Silver Oxide Surface
Electrons Emitted Toward Anode
Anode
Light Source
Electron Flow


Light Source
Semitransparent Layer Passes Light and Collects Photoelectrons
Electron Flow
Photosensitive Copper Oxide
Pure Copper Base Layer

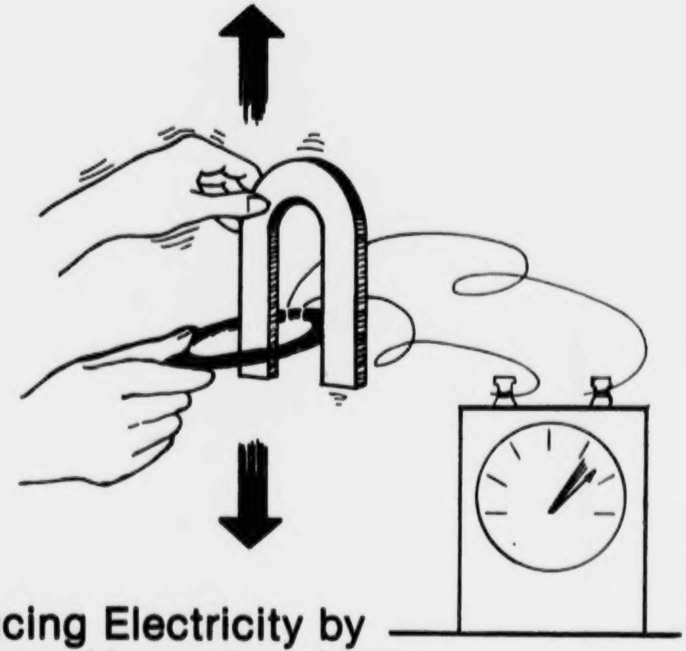
Chemical Action Produces Electricity


—
Negative Terminal
(Cathode)
+
Positive Terminal
(Anode)
Electrolyte
Ions
Cell Plates

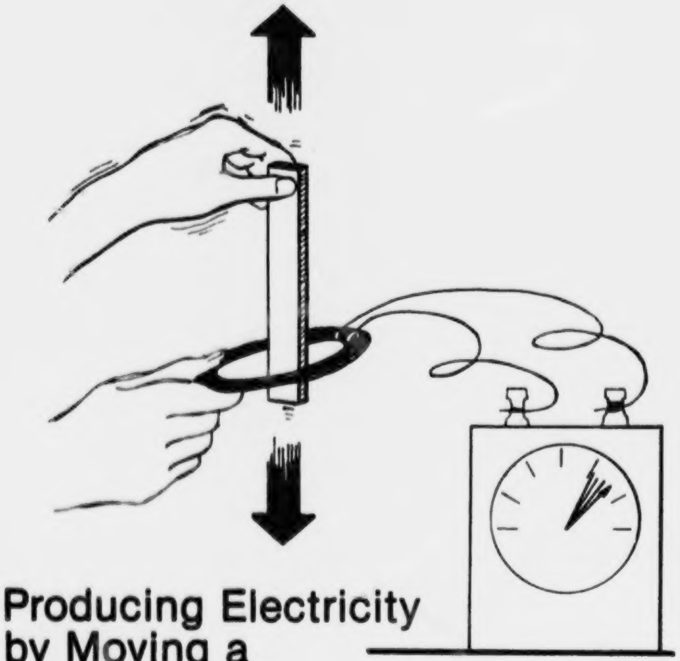
TM 5
Objective III

BW-427

Magnetism Produces Electricity



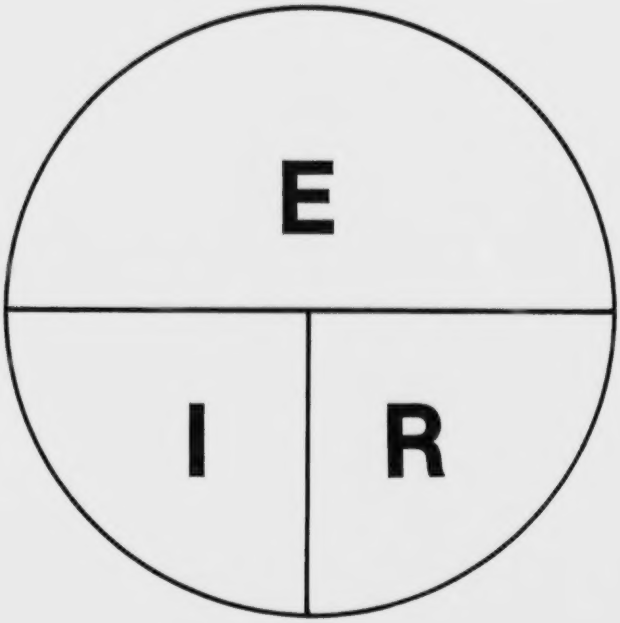
Producing Electricity by Moving a Horseshoe Magnet Through a Coil of Wire



Producing Electricity by Moving a Bar Magnet Through a Coil of Wire

This principle is used in generators.

Ohm's Law
In
Wheel Expression



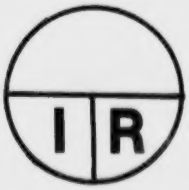
E = volts

I = amps

R = ohms

Three Formulas from Ohm's Law

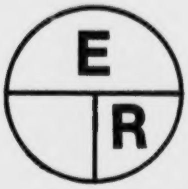
A. E =



or $E = I \times R$

or Volts = Amps × Ohms

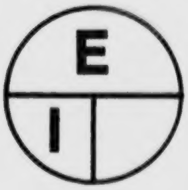
B. I =



or $I = E/R$

or Amps = Volts ÷ Ohms

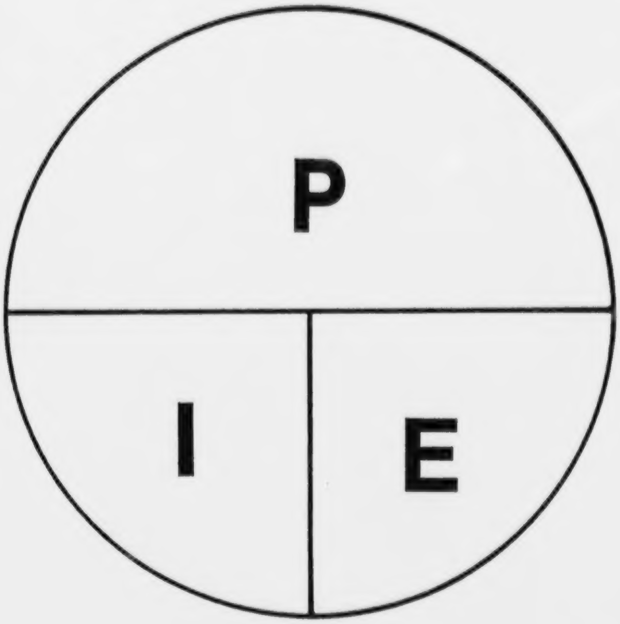
C. R =



or $R = E/I$

or Ohms = Volts ÷ Amp

Ohm's Law for Power In Wheel Expression



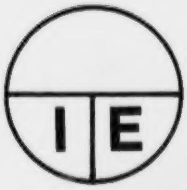
P = Watts

I = Amps

E = Volts

Three Formulas from Ohm's Law for Power

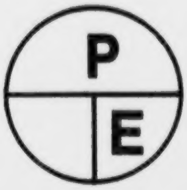
A. $P =$



or $P = I \times E$

or Watts = Amps × Volts

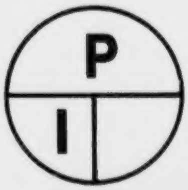
B. $I =$



or $I = P/E$

or Amps = Watts ÷ Volts

C. $E =$



or $E = P/I$

or Volts = Watts ÷ Amps

BASIC THEORY
UNIT VIII

INFORMATION SHEET

I. **Terms and definitions**

   A. Amp — Unit of measure for the intensity of the electron flow in a circuit

   B. Electricity — Invisible energy

   C. Electron flow — When electrons are transferred from one atom to another

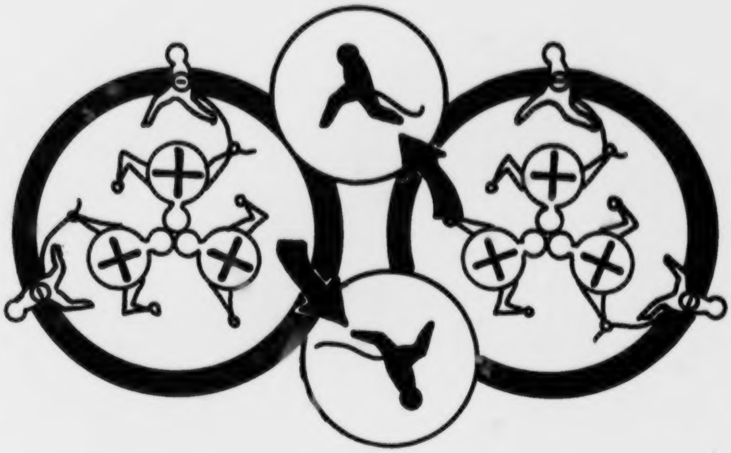
   D. Ohm — Unit of measure for the opposition to electron flow in a circuit

   E. Volt — Unit of measure of electromotive force or potential difference

   F. Watt — Unit of measure for the power of an electric circuit

II. **Principles of electron flow**

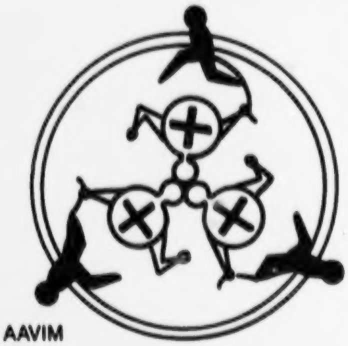
   A. Electricity is the flow of one electron to another.



Courtesy of AAVIM

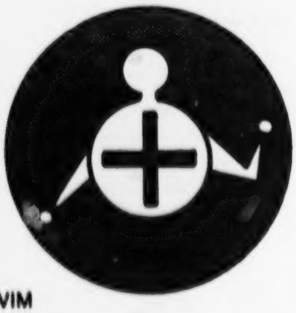
INFORMATION SHEET

B. Atoms contain both protons and electrons.



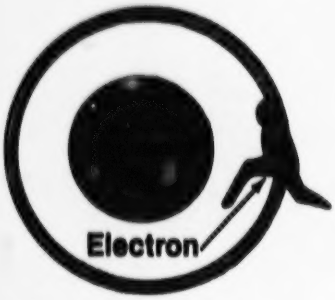
Courtesy of AAVIM

C. Protons always have a positive charge.



Courtesy of AAVIM

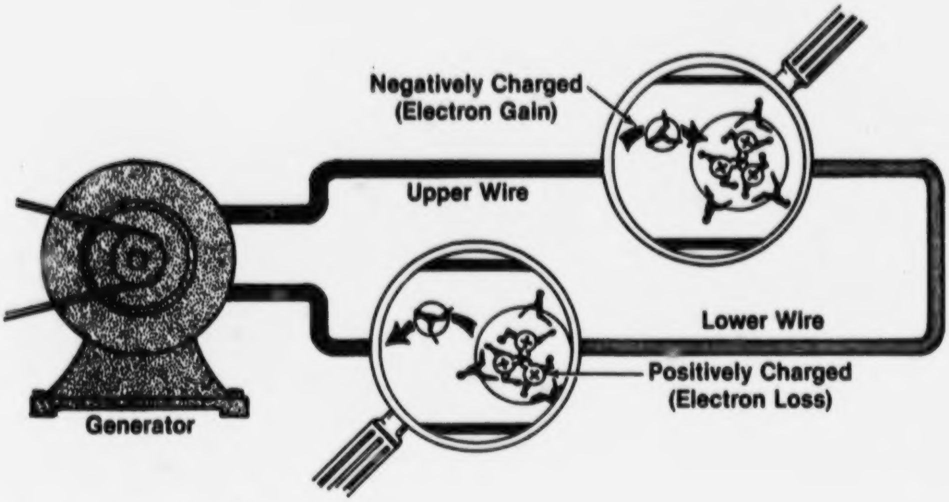
D. Electrons always have a negative charge.



Courtesy of AAVIM

INFORMATION SHEET

E. Generation occurs when an outside force of power excites the electron flow and electricity is produced.


Negatively Charged
(Electron Gain)
Upper Wire
Lower Wire
Positively Charged
(Electron Loss)
Generator

Courtesy of AAVIM

III. Basic sources of generation

A. Friction produces electricity when two materials are rubbed together.

(NOTE: This is referred to as static electricity.)

EXAMPLE: When you slide your feet across a nylon or wool carpet your shoes develop a charge which is transferred to the body.

B. Pressure produces electricity when pressure is applied to crystalline substances such as quartz or tourmaline.

EXAMPLE: A crystal microphone or in a phono cartridge on the pickup arm of a record player

C. Heat produces electricity when it is applied to the junction of two dissimilar metals.

EXAMPLE: Thermocouple used in a water heater

D. Light produces electricity when light strikes a photosensitive material.

EXAMPLE: Solar cell used on spacecraft

INFORMATION SHEET

E. Chemical action produces electricity when that action takes place between two metals in a cell.

EXAMPLE: Automobile and flashlight batteries

F. Magnetism produces electricity when a magnet is moved past a piece of wire.

EXAMPLE: Generator in a power plant or automobile

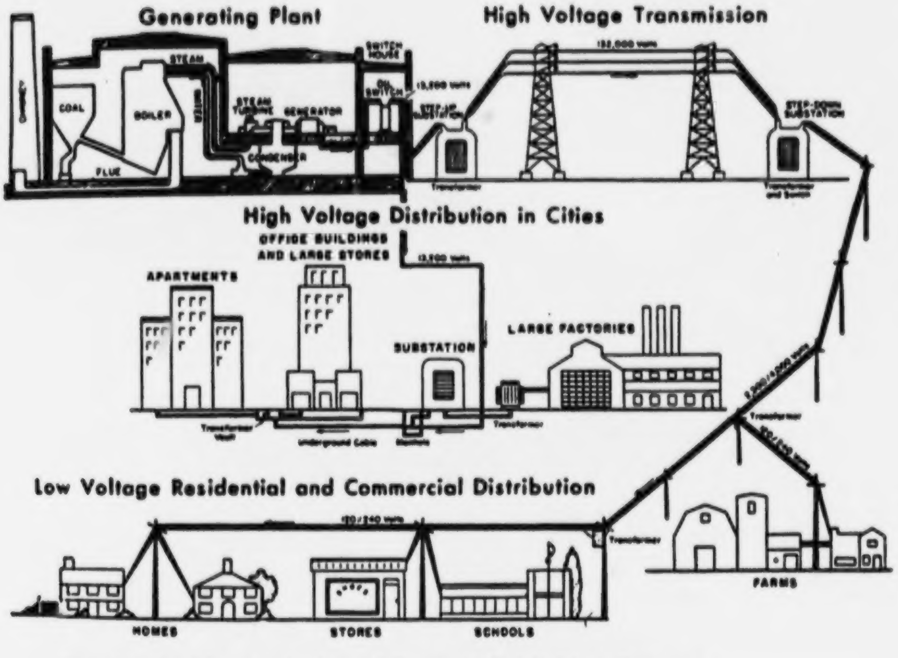
IV. **Distribution of electricity**

A. Power is produced at the generating plant.

B. Voltage is stepped-up for high voltage transmission.

C. Voltage is moved from one area to another through high voltage transmission lines.

D. Voltage is stepped-down and moved through transformers for public use.


Generating Plant
High Voltage Transmission
COAL
BOILER
STEAM
FLUE
STEAM TURBINE
GENERATOR
CONDENSER
SWITCH HOUSE
OIL SWITCH
STEP-UP SUBSTATION
Transformer
132,000 volts
STEP-DOWN SUBSTATION
Transformer and Switch
High Voltage Distribution in Cities
OFFICE BUILDINGS AND LARGE STORES
APARTMENTS
SUBSTATION
LARGE FACTORIES
Transformer Vault
Underground Cable
Manhole
Transformer
Transformer
Low Voltage Residential and Commercial Distribution
120/240 volts
Transformer
HOMES
STORES
SCHOOLS
FARMS

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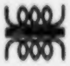
Industrial Electricity by Rex Miller, Copyright 1978.

INFORMATION SHEET

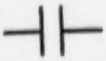
V. **Electrical schematic symbols**

A. Transformer

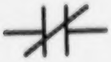


B. Contacts

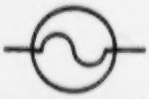
1. Normally open



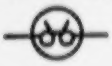
2. Normally closed



C. Fuse

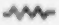


D. Fixed bimetal thermostat

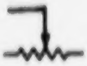


E. Resistor or load

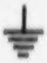
1. Fixed



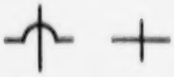
2. Variable



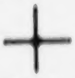
F. Ground connection



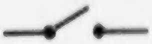
G. Wire crossover



H. Wire connection

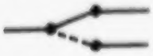


I. Single pole single throw switch

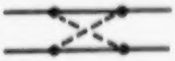


INFORMATION SHEET

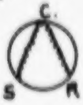
J. Three way switch



K. Four way switch

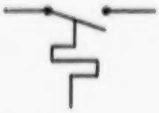


L. Single phase motor

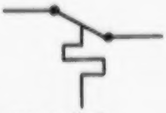


M. Thermostat

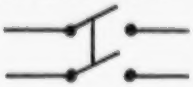
1. Closes on rise



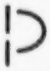
2. Opens on rise



N. Double pole single throw switch



O. Circuit breaker

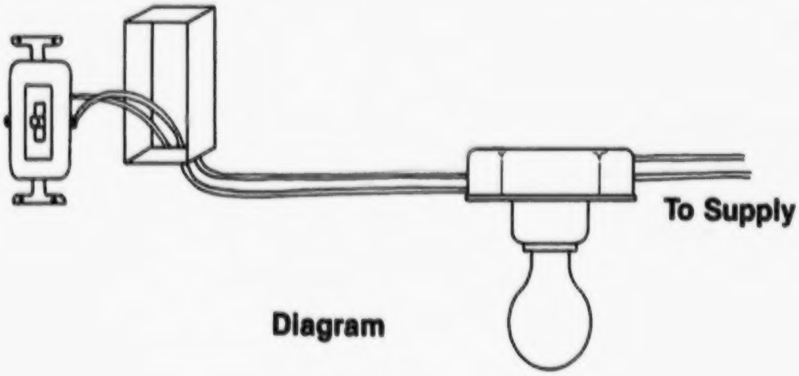


VII. **Diagrams and schematics**

A. Diagrams

1. Drawing type illustrations

2. Illustrations are of actual equipment and devices

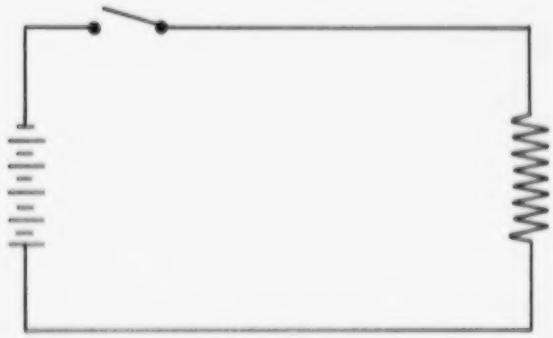


Diagram

INFORMATION SHEET

B. Schematics

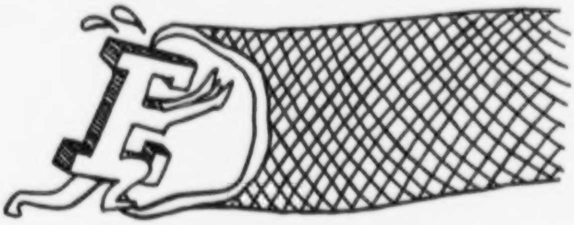
1. Line type illustrations
2. Use standard schematic symbols for equipment and devices



Schematic

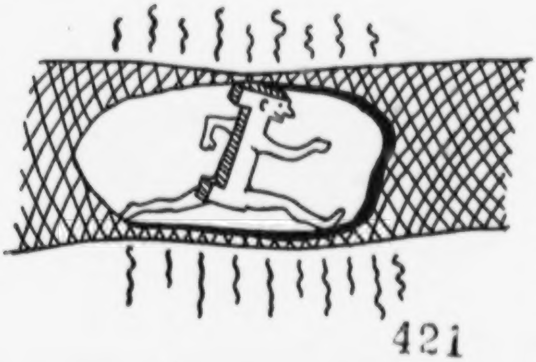
VII. **Letters and terms**

A. E — Electromotive force (Emf) in volts



Voltage is pressure, or electromotive force.

B. I — Intensity in amps



Current is the rate of flow of electrons.

INFORMATION SHEET

C. R — Resistance in ohms

Resistance is opposition to current flow.

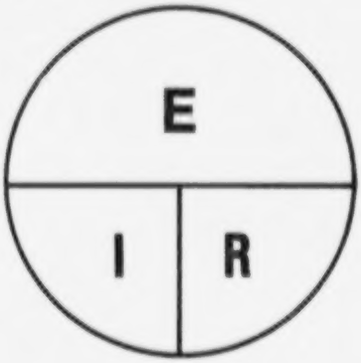
D. P — Power in watts

Combining volts and amperes produces a measurement of power.

VIII. **Ohm's law** — The current in an electric circuit equals the pressure (volts) divided by the resistance.

(NOTE: It takes one volt to push one amp through one ohm of resistance.)

IX. **Ohm's law in wheel expression**



X. **Uses of Ohm's law**

A. Calculating circuit resistance

B. Calculating circuit amperage

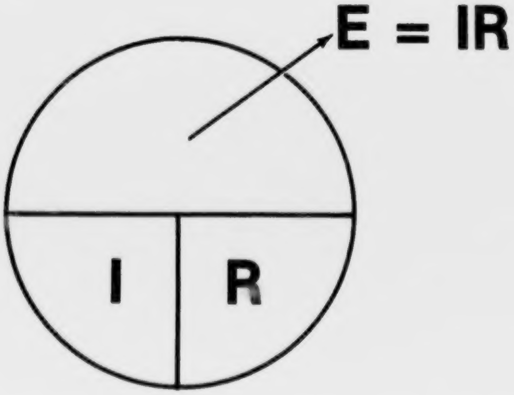
C. Calculating circuit voltage

INFORMATION SHEET

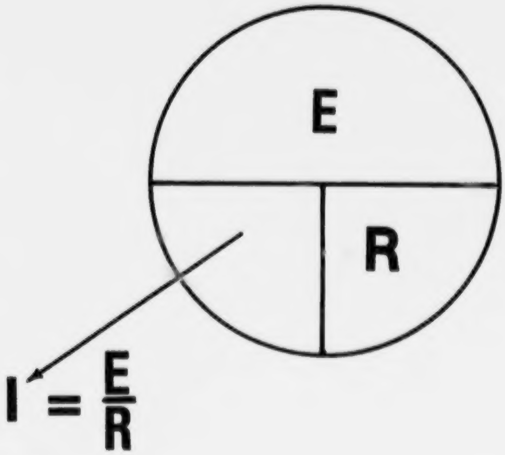
XI. Formulas from Ohm's law

(NOTE: When you cover the unknown in the wheel representation of Ohm's law, the remaining letters give you the problem solving equation.)

A. Volts = Amps × Ohms or $E = I \times R$

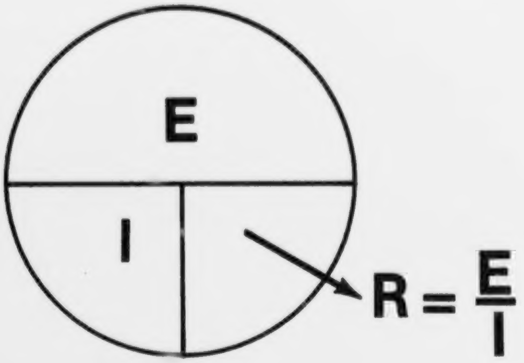


B. Amps = Volts ÷ Ohms or $I = E/R$



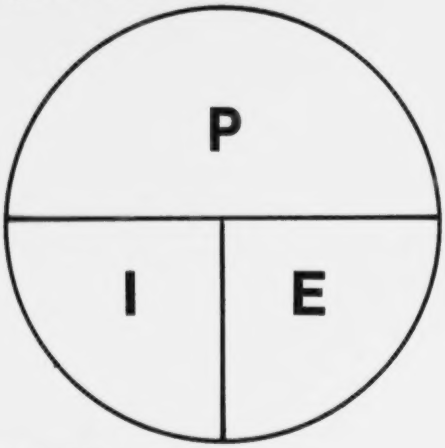
INFORMATION SHEET

C. Ohms = Volts + Amps or R = E/I



XII. **Ohm's law for power** — The power in an electrical circuit equals the amperes divided by the volts.

XIII. **Ohm's law for power in wheel expression**



P = Watts

I = Amps

E = Volts

XIV. **Uses of Ohm's law for power**

A. Calculating circuit wattage

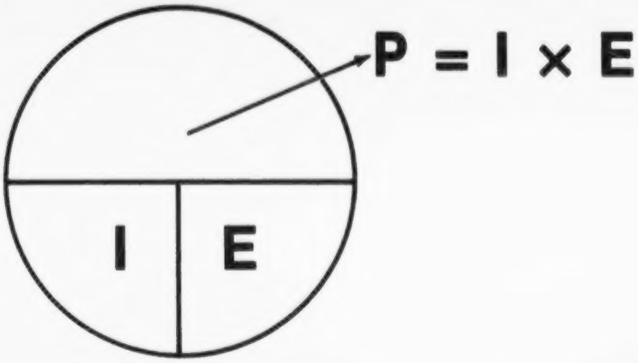
B. Calculating circuit voltage

C. Calculating circuit amperage

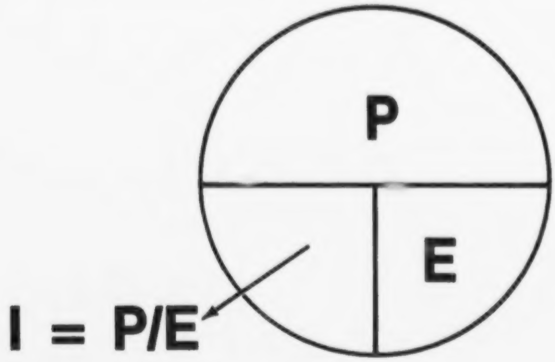
INFORMATION SHEET

XV. Formulas from Ohm's law for power

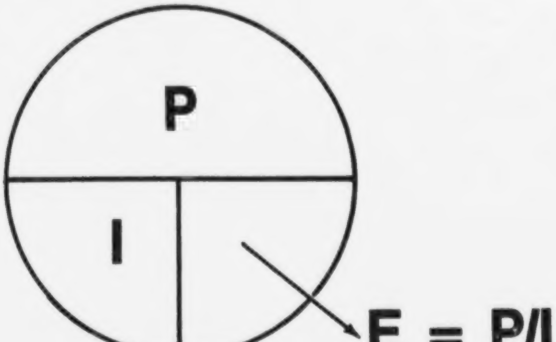
A. Watts = Amps × Volts or $P = I \times E$



B. Amps = Watts ÷ Volts or $I = P/E$



C. Volts = Watts ÷ Amps or $E = P/I$



BASIC THEORY
UNIT VIII

ASSIGNMENT SHEET #1 — DRAW A DIAGRAM OF THE POWER DISTRIBUTION SUPPLYING YOUR SCHOOL SHOP

NAME ______________________________ SCORE ______________

Directions: Draw a diagram showing the power distribution supplying your school shop. Refer to Objective IV for assistance in completing this assignment.

BASIC THEORY
UNIT VIII

ASSIGNMENT SHEET #2 — SOLVE PROBLEMS FOR AN UNKNOWN VOLTAGE

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula from Ohm's law to find the voltage. Show calculations beside each problem.

Example 1: 2 amps, 60 Ohms = ____ volts
Answer: 2 × 60 = 120

Example 2: 2 amps, 240 watts = ____ volts
Answer: 240 ÷ 2 = 120

Problems:

	Amps	Ohms		Volts	Calculations
1.	20	6	=	____	
2.	4	60	=	____	
3.	9.6	2.5	=	____	
4.	5	2.4	=	____	
	Amps	Watts			
5.	6	1380	=	____	
6.	6.5	715	=	____	
7.	2.5	1100	=	____	
8.	5	600	=	____	
9.	7	805	=	____	
10.	4	500	=	____	

BASIC THEORY
UNIT VIII

ASSIGNMENT SHEET #3 — SOLVE PROBLEMS FOR AN UNKNOWN AMPERAGE

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula to find the amperage. Show calculations beside each problem.

Example 1: 120 volts, 40 Ohms = ________ amps
Answer: 120 ÷ 4 = 30

Example 2: 120 watts, 120 volts = ________ amps
Answer: 120 ÷ 120 = 1

Problems:

	Volts	Ohms		Amps	Calculations
1.	230	12	=		
2.	110	11	=		
3.	440	20	=		
4.	120	40	=		
5.	24	3	=		
	Watts	Volts			
6.	6,000	120	=		
7.	2,640	240	=		
8.	8,800	440	=		
9.	690	115	=		
10.	2,760	230	=		

BASIC THEORY
UNIT VIII

ASSIGNMENT SHEET #4 — SOLVE PROBLEMS FOR UNKNOWN RESISTANCES AND WATTAGES

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula to solve the problem. Show calculations beside each problem.

Example 1: 440 volts, 10 amps = ________ ohms
Answer: 440 ÷ 10 = 44

Example 2: 115 volts, 12 amps = ________ watts
Answer: 115 × 12 = 1,380

Problems:

	Volts	Amps	Ohms	Calculations
1.	240	4		
2.	24	9.6		
3.	12	5		
4.	230	5		
5.	24	8		

	Volts	Amps	Watts	Calculations
6.	240	11		
7.	115	6		
8.	440	20		
9.	230	50		
10.	24	.5		

BASIC THEORY
UNIT VIII

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1 — Evaluated to the satisfaction of the instructor

Assignment Sheet #2

1. 120
2. 240
3. 24
4. 12
5. 230
6. 110
7. 440
8. 120
9. 115
10. 125

Assignment Sheet #3

1. 19.2
2. 10
3. 22
4. 3
5. 8
6. 50
7. 11
8. 20
9. 6
10. 12

Assignment Sheet #4

1. 60
2. 2.5
3. 2.4
4. 46
5. 3
6. 2640
7. 690
8. 8800
9. 11,500
10. 12

BASIC THEORY
UNIT VIII

TEST

NAME ________________________________ SCORE ____________

1. Match the terms on the right with their correct definitions.

_____a. Invisible energy

_____b. Unit of measure for the power of an electric circuit

_____c. Unit of measure for the intensity of the electron flow in a circuit

_____d. When electrons are transferred from one atom to another

_____e. Unit of measure for the opposition to electron flow in a circuit

_____f. Unit of measure of electromotive force or potential difference

1. Amp
2. Electricity
3. Electron flow
4. Ohm
5. Volt
6. Watt

2. Select true statements concerning the principles of electron flow by placing an "X" in the blanks preceding the true statements.

_____a. Electricity is the flow of one electron to another.

_____b. Atoms contain both protons and electrons.

_____c. Protons always have a negative charge.

_____d. Electrons always have a positive charge.

_____e. Generation occurs when an outside force of power excites the electron flow and electricity is produced.

TEST

3. Complete the following list of statements concerning basic sources of generation by circling the word(s) that best complete(s) each statement.

   a. (**Chemical action, Friction**) produces electricity when two materials are rubbed together.

   b. Pressure produces electricity when pressure is applied to (**crystalline, magnetic**) substances.

   c. Heat produces electricity when it is applied to the junction of two (**similar, dissimilar**) metals.

   d. Light produces electricity when light strikes a (**reflective, photosensitive**) material.

   e. (**Chemical action, Friction**) produces electricity when that action takes place between two metals in a cell.

   f. Magnetism produces electricity when a magnet is moved past (**another magnet, a piece of wire**)

4. Complete the following list of statements concerning distribution of electricity by inserting the words that best complete each statement.

   a. Power is produced at the ______________ ______________.

   b. Voltage is ______________ ______________ for high voltage transmission.

   c. Voltage is moved from one area to another through high voltage ______________ ______________.

   d. Voltage is stepped-down and moved through ______________ for public use.

TEST

5. Match the electrical schematic symbols on the right with their correct names.

_____a. Contacts
  1) Normally open
  2) Normally closed

_____b. Fixed bimetal thermostat

_____c. Ground connection

_____d. Single pole single throw switch

_____e. Single phase motor

_____f. Thermostat
  1) Closes on rise
  2) Opens on rise

_____g. Transformer

_____h. Fuse

_____i. Resistor or load
  1) Fixed
  2) Variable

_____j. Wire connection

_____k. Three way switch

_____l. Circuit breaker

_____m. Double pole single throw switch

_____n. Four way switch

_____o. Wire crossover

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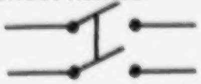

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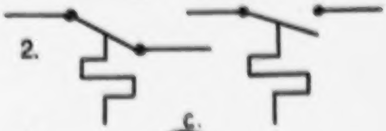

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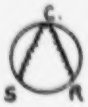

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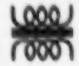

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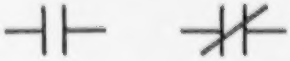

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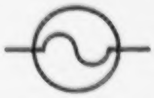

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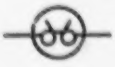

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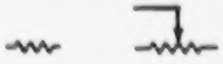

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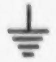

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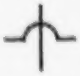

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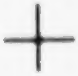

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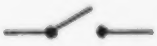

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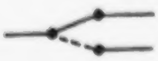

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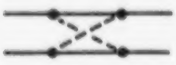

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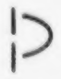


TEST

6. Distinguish between diagrams and schematics by placing a "D" for diagrams next to the correct description.

   _____a. Drawing type illustrations which are of actual equipment and devices

   _____b. Line type illustrations which use symbols for equipment and devices

7. Complete the following list of letters and their terms by circling the correct words.

   a. E — Electromotive force in **(watts, volts)**

   b. I — Intensity in **(amps, ohms)**

   c. R — Resistance in **(volts, ohms)**

   d. P — Power in **(watts, amps)**

8. State Ohm's law.

   ____

   ____

   ____

9. Draw Ohm's law in wheel expression.

10. List three uses of Ohm's law.

    a. ____

    b. ____

    c. ____

TEST

11. State the formulas from Ohm's law.

    a. Volts = ______

    b. Amps = ______

    c. Ohms = ______

12. State Ohm's law for power.

    ______

    ______

    ______

13. Draw Ohm's law for power in wheel expression.

14. List three uses of Ohm's law for power.

    a. ______

    b. ______

    c. ______

15. State the formulas from Ohm's law for power.

    a. Watts = ______

    b. Amps = ______

    c. Volts = ______

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

16. Draw a diagram of the power distribution supplying your school shop. (Assignment Sheet #1)

17. Solve problems for an unknown voltage. (Assignment Sheet #2)

18. Solve problems for an unknown amperage. (Assignment Sheet #3)

19. Solve problems for unknown resistances and wattages. (Assignment Sheet #4)

BASIC THEORY
UNIT VIII

ANSWERS TO TEST

1. a. 2
   b. 6
   c. 1
   d. 3
   e. 4
   f. 5

2. a, b, e

3. a. Friction
   b. Crystalline
   c. Dissimilar
   d. Photosensitive
   e. Chemical action
   f. A piece of wire

4. a. Generating plant
   b. Stepped-up
   c. Transmission lines
   d. Transformers

5. a. 5
   b. 7
   c. 9
   d. 12
   e. 3
   f. 2
   g. 4
   h. 6
   i. 8
   j. 11
   k. 13
   l. 15
   m. 1
   n. 14
   o. 10

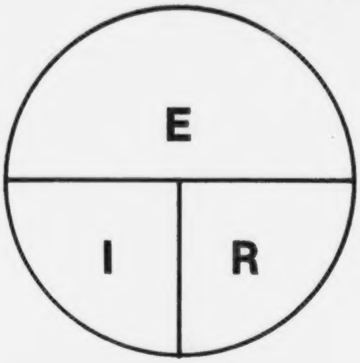
6. a

7. a. Volts
   b. Amps
   c. Ohms
   d. Watts

8. **Ohm's law** — The current in an electric circuit equals the pressure (volts) divided by the resistance.

ANSWERS TO TEST

9.

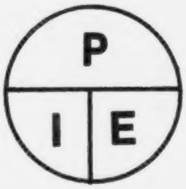


10. a. Calculating circuit resistance
    b. Calculating circuit amperage
    c. Calculating circuit voltage

11. a. Volts = Amps × Ohms or $E = I \times R$
    b. Amps = Volts ÷ Ohms or $I = E/R$
    c. Ohms = Volts ÷ Amps or $R = E/I$

12. **Ohm's law for power** — The power in an electrical circuit equals the amperes divided by the volts.

13.



14. a. Calculating circuit wattage
    b. Calculating circuit voltage
    c. Calculating circuit amperage

15. a. Watts = Amps × Volts or $P = I \times E$
    b. Amps = Watts ÷ Volts or $I = P/E$
    c. Volts = Watts ÷ Amps or $E = P/I$

16.-19. Evaluated to the satisfaction of the instructor

DC CIRCUITS
UNIT IX

UNIT OBJECTIVE

After completion of this unit, the student should be able to use Ohm's and Kirchoff's laws to solve problems for unknown current, resistance, and voltage in DC circuits. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to DC circuits with their correct definitions.
2. List applications of DC circuits.
3. State the application of Ohm's law to DC.
4. Select true statements concerning characteristics of series circuits.
5. Complete the three basic formulas for Watt's law.
6. State Kirchoff's voltage law.
7. Select true statements concerning characteristics of parallel circuits.
8. State Kirchoff's current law.
9. Complete statements concerning characteristics of series-parallel circuits.
10. Select true statements concerning facts about magnetism.
11. Solve problems for an unknown current. (Assignment Sheet #1)

OBJECTIVE SHEET

12. Solve problems for an unknown resistance. (Assignment Sheet #2)
13. Solve problems for an unknown voltage. (Assignment Sheet #3)
14. Determine the total resistance in a series circuit. (Assignment Sheet #4)
15. Determine unknown resistor values in a series circuit. (Assignment Sheet #5)
16. Solve problems for unknown current in a series circuit. (Assignment Sheet #6)
17. Solve problems for unknown resistance in a series circuit. (Assignment Sheet #7)
18. Solve problems for unknown voltage in a series circuit. (Assignment Sheet #8)
19. Apply Kirchoff's voltage law to series circuits. (Assignment Sheet #9)
20. Solve problems for unknown resistance in a parallel circuit. (Assignment Sheet #10)
21. Solve problems for unknown current in a parallel circuit. (Assignment Sheet #11)
22. Apply Kirchoff's current law to parallel circuits. (Assignment Sheet #12)
23. Solve problems for unknown resistance in a series-parallel circuit. (Assignment Sheet #13)
24. Solve problems for unknown voltage in a series-parallel circuit. (Assignment Sheet #14)
25. Solve problems for unknown current in a series-parallel circuit. (Assignment Sheet #15)
26. Compute power using Ohm's power law. (Assignment Sheet #16)

DC CIRCUITS
UNIT IX

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

  1. Show a film related to DC circuit fundamentals.
  2. Have students work DC circuits on the blackboard.
  3. Set up a display of various resistors and explain their functions.
  4. Demonstrate the principles of magnetism, electromagnetism, and polarity and explain their relationship to electricity.
  5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. Adams/Rockmaker. *Industrial Electricity*. Brooklyn, NY: McGraw-Hill Book Company, 1985.

B. *DC Fundamentals Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1981.

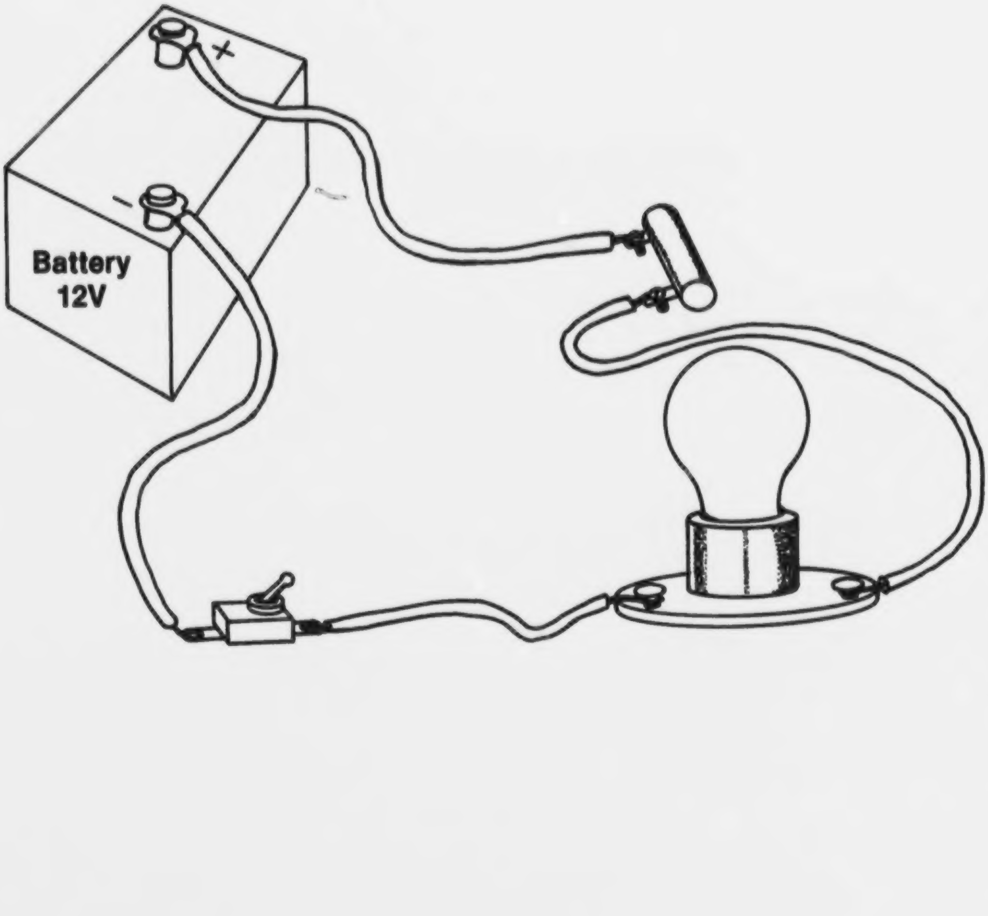
C. *Electromagnetic Induction Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1980.

D. Vorderstrasse, Ron. *General Electronics Technician*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

SUGGESTED SUPPLEMENTAL MATERIAL

Film — *DC Fundamentals Review*. NUS Training Corporation, 1350 Piccard Drive, Rockville, MD 20850.

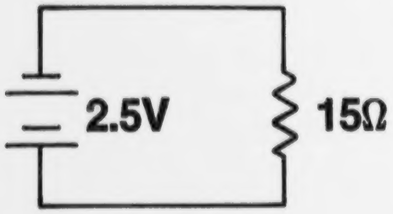
Series Circuit


+
–
Battery
12V

Applying Watts Law

When Voltage and resistance is known

$$\left(P = \frac{E_2}{R}\right)$$



$E = 2.5V$

$R = 15\Omega$

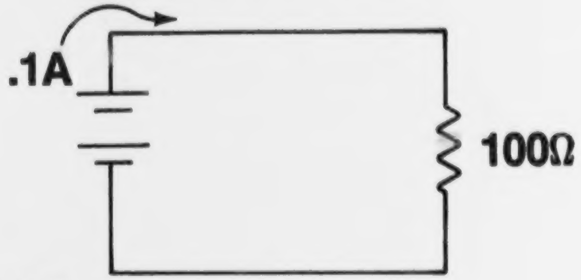
$$P = \frac{E_2}{R}$$

$$P = \frac{(2.5)^2}{15} = \frac{2.5 \times 2.5}{15} = .417\ W$$

$P = .417$ Watt

When current and resistance is known

$$P = I^2 \times R$$



$R = 100\Omega$

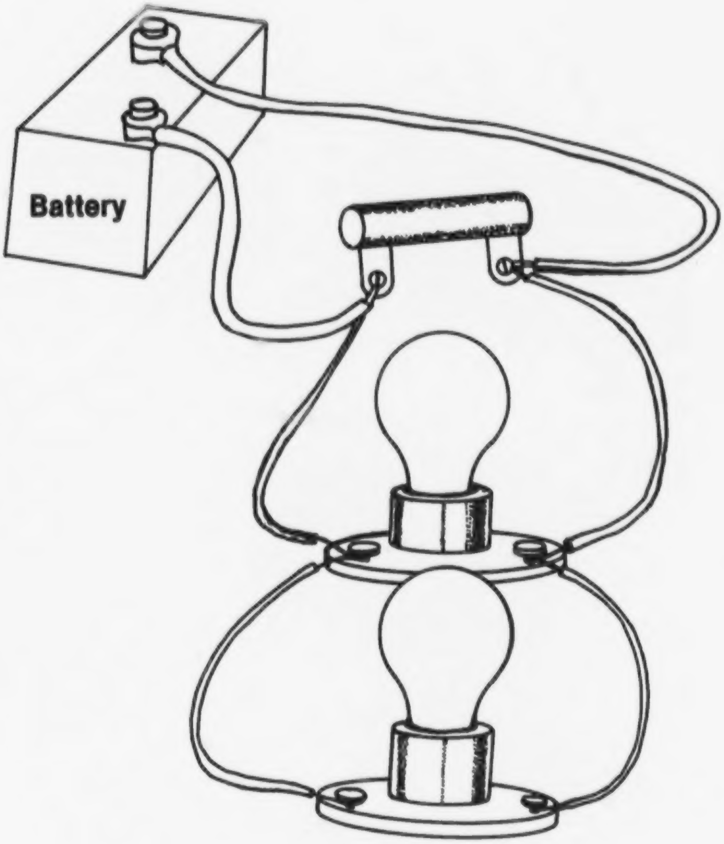
$I = .1A$

$P = I^2 \times R$

$$P = 0.1 \times 100 = 0.1 \times 0.1 \times 100 = 1\ W$$

$P = 1$ Watt

Parallel Circuit



DC CIRCUITS
UNIT IX

INFORMATION SHEET

I. **Terms and definitions**

A. Amperage — Measurement of the rate of flow of current through a conductor

B. Circuit — A complete path for current to flow from the source through the load and back to the source

C. Conductors — Materials which permit the free flow of electrons

D. DC — Abbreviation for direct current

E. Domains — Molecules that act as small magnets when arranged end to end

F. Electromagnet — A magnet made by winding a conductor around a metal core with voltage applied

G. Flux lines — Power around a magnet

H. Formula — A mathematical expression used to find unknowns

I. Magnetism — Property possessed by certain materials which exerts a mechanical force on other magnetic materials, and which can cause induced voltage in conductors when relative movement is present

J. Parallel circuit — A circuit which provides more than one path for current to flow

K. Polarity — When magnetism leaves a body north and enters south

EXAMPLE: When using a VOM, the red lead always connects to the positive and black lead always connects to the negative

L. Power — Rate of consumption of energy

M. Resistance — Opposition to electron flow in a conductor or circuit

(NOTE: Electron flow in a circuit always travels from positive to negative.)

N. Series circuit — A circuit where the same current passes through each component

O. Series-parallel circuit — A circuit that contains some components in series and some in parallel

INFORMATION SHEET

P. Voltage — The measurement of the potential difference between conductors in a circuit

Q. Voltage drop — Reduction in circuit potential difference due to resistance

II. **Applications of DC circuits**

A. Industrial locations for controls and power

B. Moving of materials and parts

C. Home appliances, radio, television, and stereo equipment

D. Automobile and truck systems

E. Telephone and communications circuits

F. Computers and electronic equipment

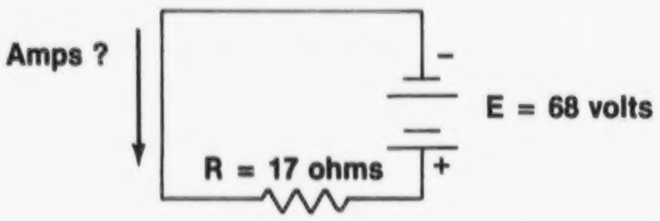
G. Airplanes for control and power systems

H. Medical field

I. Power for electric carts and battery charges

III. **Application of Ohm's law to DC**

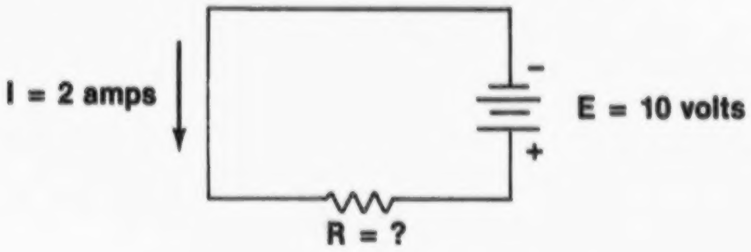
A. Ohm's law for computing current (I) — I = E/R



$$I = 4 \text{ amps} \quad \frac{68 \text{ volts}}{17 \text{ ohms}} = 4 \text{ amperes}$$

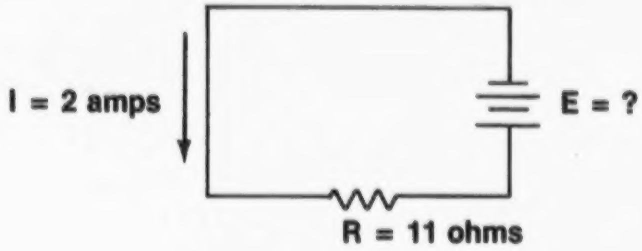
INFORMATION SHEET

B. Ohm's law for computing resistance (R) — R = E/I



R = 5 ohms $\quad \frac{\text{10 volts}}{\text{2 amperes}} = \text{5 ohms}$

C. Ohm's law for computing voltage (E) — E = I × R

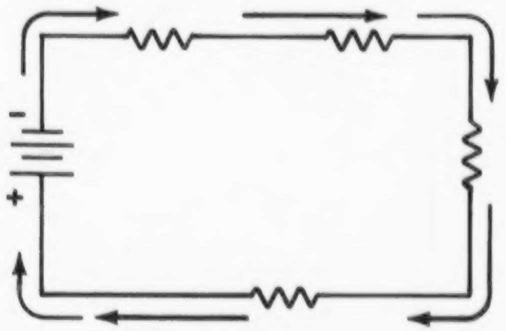


E = 22 volts $\quad$ 2 amps × 11 ohms = 22 volts

IV. **Characteristics of series circuits**

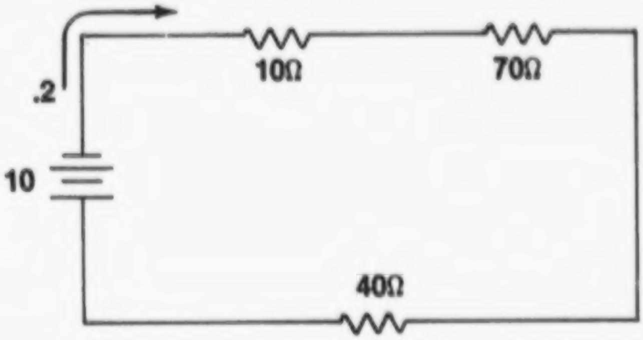
A. A series circuit will only let current flow one way. The components are connected end to end forming a continuous loop going back to the power source.

EXAMPLE:



INFORMATION SHEET

B. A combination of resistors in series is called resistancesting.

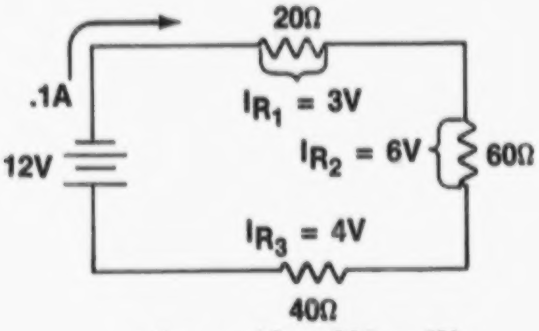


(NOTE: When the voltage and current is given, the total resistance can be calculated using Ohm's law.)

$$R = \frac{E}{I} \qquad R = \frac{10V}{.2A} \qquad R = 50\Omega \text{ (ohms)}$$

C. When current travels through a resistor, the voltage drop across each resistor is equal to the current times the resistance (E = I × R).

EXAMPLE:

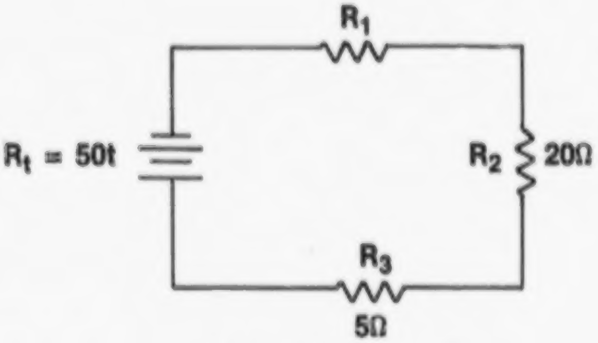


$$\begin{aligned} I_{R_1} &= .1A \times 20\Omega = 2V \\ &.1A \times 60\Omega = 6V \\ &.1A \times 40\Omega = 4V \end{aligned}$$

INFORMATION SHEET

D. In a series circuit, the formula ($R_1 = R_t - R_2 - R_3$) may be used to find an individual resistance if the total resistance and the resistances of the other components are known.

EXAMPLE:

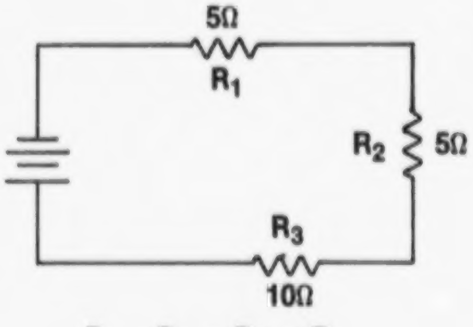


$$R_1 = R_t - R_2 - R_3$$

$$R_1 = 50\Omega - 20\Omega - 5\Omega$$

E. When totaling resistances in a series circuit, the sum of each resistance in the circuit can be mathematically stated ($R_t = R_1 + R_2 + R_3$)

EXAMPLE:



$$R_t = R_1 + R_2 + R_3$$

$$R_t = 5\Omega + 5\Omega + 10\Omega$$

$$R_t = 20\Omega$$

INFORMATION SHEET

V. **Watt's law** — Power in an electrical circuit may be calculated by using this law which is expressed by three basic formulas:

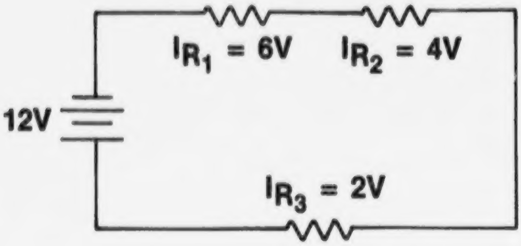
P (in watts) = E (volts) × I (amperes)

P (in watts) = I^2 (amperes) × R (ohms)

$$P \text{ (in watts)} = \frac{E^2 \text{ (volts)}}{R \text{ (ohms)}}$$

VI. **Kirchoff's voltage law** — The sum of the individual voltage drops in a series circuit is equal to the applied voltage.

EXAMPLE:



The I_R voltage drops are 6 volts, 4 volts, and 2 volts.

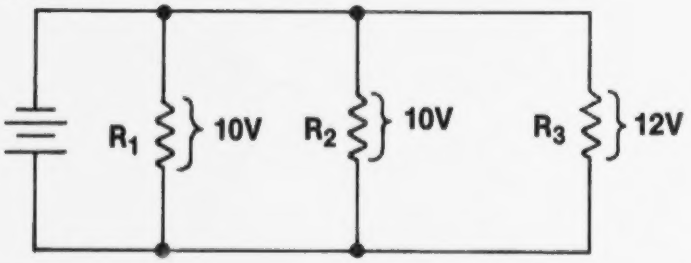
$$E_t = I_{R_1} + I_{R_2} + I_{R_3}$$
$$12V = 6V + 4V + 2V$$
$$12V - 12V$$

INFORMATION SHEET

VII. Characteristics of parallel circuits

A. A parallel circuit has more than one path of current flow. When more than one load is connected across two lines, this is known as a parallel circuit.

EXAMPLE:

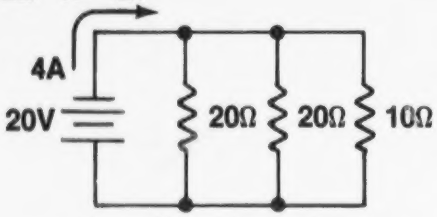


B. Voltage drop in a parallel circuit is the drop over the entire circuit. The voltage remains the same throughout the entire system.

C. Total resistance in a parallel circuit is always less than any branch resistance. By using Ohm's law we can calculate the total resistance.

(NOTE: When total current and total voltage are given, total resistance may be calculated as shown in the example.)

EXAMPLE: R = E/I



$$\frac{1}{R_t} = \frac{1}{R_t} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_t} = \frac{1}{20} + \frac{1}{20} + \frac{1}{10}$$

$$\frac{1}{R_t} = \frac{1}{20} + \frac{1}{20} + \frac{2}{20}$$

$$\frac{1}{R_t} = \frac{5}{20}$$

4 amps

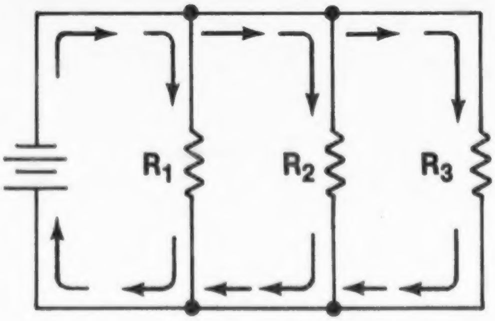
D. Reciprocals are used in figuring resistance. Reciprocals are any fraction turned upside down.

EXAMPLE: Reciprocal of 3 is $^1/_3$
Reciprocal of $^3/_4$ is $^4/_3$

INFORMATION SHEET

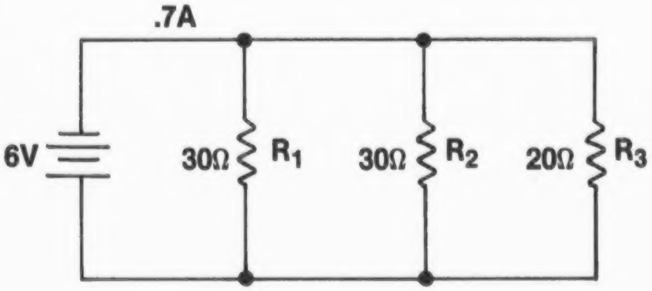
E. Parallel branch circuits differ from series circuits as there are many different paths for the current to follow.

EXAMPLE:



F. When voltage and the resistance of each branch are known, the branch currents may be calculated by Ohm's law (I = E/R)

EXAMPLE:



Calculations for R_1:

$I = E/R$ $I_{R_1} = E/R_1$ $I_{R_1} = 6V/30\Omega$ $I_{R_1} = .2$ amps

Calculations for R_2:

$I_{R_2} = E/R_2$ $I_{R_2} = 6V/30\Omega$ $I_{R_1} = .2$ amps

Calculations for R_3:

$I_{R_3} = E/R_3$ $I_{R_3} = 6V/20\Omega$ $I_{R_3} = .3$ amps

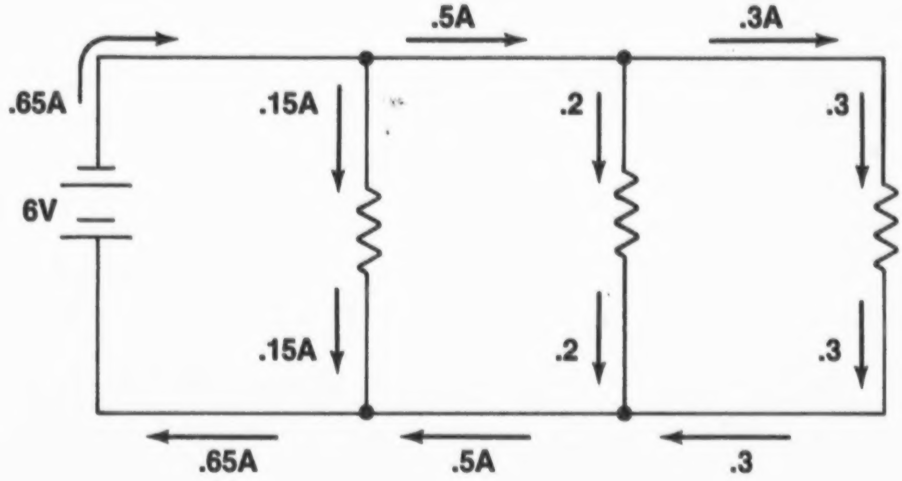
INFORMATION SHEET

G. The total of all three branch currents may now be put into a formula for total current.

EXAMPLE: $I_t = I_{R_1} + I_{R_2} + I_{R_3}$
$.7 = .2A + .2A + .3A$
$.7a = 7.a$

VIII. **Kirchoff's current law** — The sum of the currents through the individual branches of a parallel circuit is equal to the total current of the circuit ($I_t = I_{R_1} + I_{R_2} + I_{R_3}$.).

EXAMPLE:



$I_t = I_{R_1} + I_{R_2} + I_{R_3}$
$.65A = .15A + .2A + .3A$
$.65A = 65A$

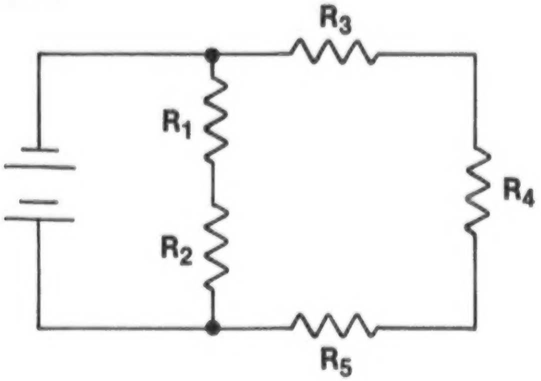
(NOTE: The total is .65A and the sum of the branch circuits is .65A.)

INFORMATION SHEET

IX. Characteristics of series-parallel circuits

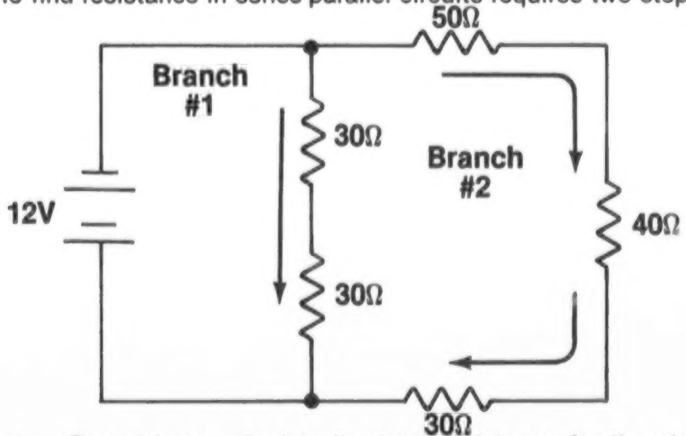
A. A series-parallel circuit is a circuit used with both series circuits and parallel circuits connected.

EXAMPLE:



(NOTE: Series-parallel circuits must be simplified before the values can be calculated.)

B. To find resistance in series-parallel circuits requires two steps.



1. Step 1 is to calculate the total resistance for the circuit and add together the series resistances in each branch. In circuit #1 the series resistances are 20Ω and 10Ω.

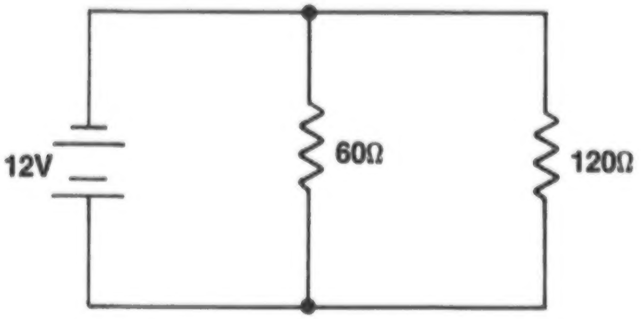
   Formula: R branch #1 = 30Ω + 30Ω
   R branch #1 = 60Ω

   In circuit #2 the series resistances are 50Ω + 40Ω + 30Ω.

   Formula: R branch #2 = 50Ω + 40Ω + 30Ω
   R branch #2 = 120Ω

INFORMATION SHEET

2. Step 2 is to redraw the circuit to use only one resistance in each branch.



3. The resistance for the circuit may now be calculated by combining the parallel resistances.

Formula:

$$\frac{1}{R_t} = \frac{1}{R_{\text{branch \#1}}} + \frac{1}{R_{\text{branch \#2}}}$$

$$\frac{1}{R_t} = \frac{2}{120} + \frac{1}{120}$$

$$\frac{1}{R_t} = \frac{2}{120} + \frac{1}{120}$$

$$\frac{1}{R_t} = \frac{3}{120}$$

$$\frac{1}{R_t} = \frac{1}{40}$$

$$R_t = 40\Omega$$

X. **Facts about magnetism**

A. There are two basic kinds of magnetism:

1. Naturally magnetic minerals called lodestones
2. Electromagnets which are man-made from steel cores with wire windings and are produced by electricity

INFORMATION SHEET

B. Molecules called domains act as small magnets if properly arranged.

C. A magnet is composed of lines of power around the magnetic field called flux lines.

D. Magnetic flux lines have four magnetic fields:

1. When north pole is put to south pole, they attract.
2. When north pole and north pole are aligned, they repel.
3. When south pole and south pole are aligned, they repel.
4. Magnetic attraction varies with pole strength and distance.

E. Electromagnets are used for iron lifting, opening contactors, valves, breakers, and relays.

F. Current flow in a conductor produces magnetic lines of force around the conductor. In using the right hand rule, the thumb is extended in the direction of current flow (positive + to negative −). The fingers will then grasp the conductor in the direction of flow of the magnetic lines of force.

DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #1 — SOLVE PROBLEMS FOR AN UNKNOWN CURRENT

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided below each problem.

1. In a circuit having a 60 ohm resistor and a voltage of 15V, what is the current?

   ____

2. In a circuit having a 30 ohm resistor and a voltage of 24V, what is the current?

   ____

3. In a circuit having a 20 ohm resistor and a voltage of 12V, what is the current?

   ____

4. In a circuit having a 60 ohm resistor and a voltage of 120V, what is the current?

   ____

5. In a circuit having a 90 ohm resistor and a voltage of 80V, what is the current?

   ____

DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #2 — SOLVE PROBLEMS FOR AN UNKNOWN RESISTANCE

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula from Ohm's law to find resistance in the following problems. Show calculations in the space provided below each problem.

1. Compute the resistance in a circuit with 12V and 2 amps. __________
2. Compute the resistance in a circuit with 120V and 5 amps. __________
3. Compute the resistance in a circuit with 100V and 15 amps. __________
4. Compute the resistance in a circuit with 24V and 1 amps. __________
5. Compute the resistance in a circuit with 16V and .2 amps. __________

DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #3 — SOLVE PROBLEMS FOR AN UNKNOWN VOLTAGE

NAME ________________________________ SCORE ______________

Directions: Apply the appropriate formula from Ohm's law to find the voltage in the following problems. Show calculations in the space provided below each problem.

1. Find the voltage in a circuit having 5 amps and 100 ohms. ____________

2. Find the voltage in a circuit having 10 amps and 80 ohms. ____________

3. Find the voltage in a circuit having 20 amps and 60 ohms. ____________

4. Find the voltage in a circuit having 70 amps and 40 ohms. ____________

5. Find the voltage in a circuit having 40 amps and 20 ohms. ____________

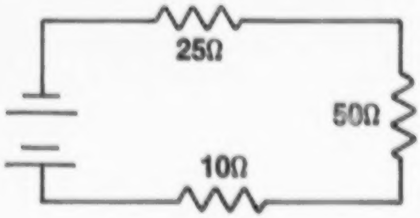
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #4 — DETERMINE THE TOTAL RESISTANCE IN A SERIES CIRCUIT

NAME ______________________________ SCORE ______________

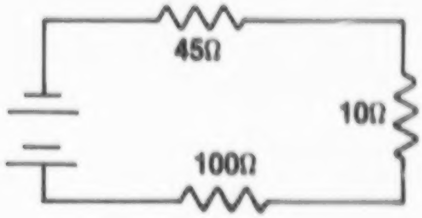
Directions: Determine the total resistance in the following series circuits using the appropriate formula from Ohm's law. Show calculations in the space provided above each answer.

1.



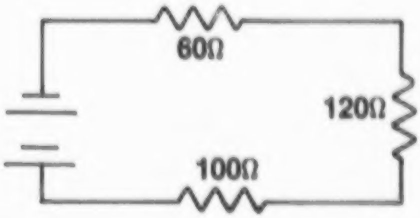
Answer ______________

2.


45Ω
10Ω
100Ω

Answer ______________

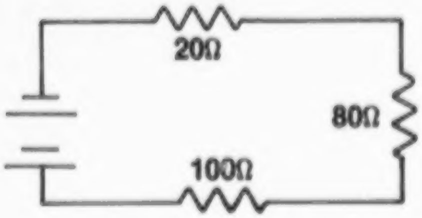
3.


60Ω
120Ω
100Ω

Answer ______________

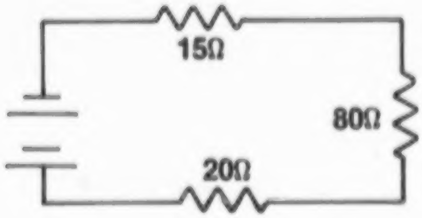
ASSIGNMENT SHEET #4

4.


20Ω
80Ω
100Ω

Answer ____________________

5.



Answer ____________________

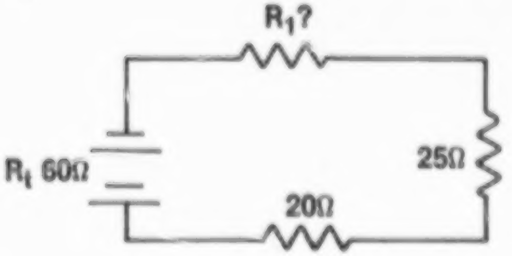
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #5 — DETERMINE UNKNOWN RESISTOR VALUES IN A SERIES CIRCUIT

NAME ______________________ SCORE ____________

Directions: Study the following schematics and determine unknown circuit values using the appropriate formula from Ohm's law. Show calculations in the space provided above each answer.

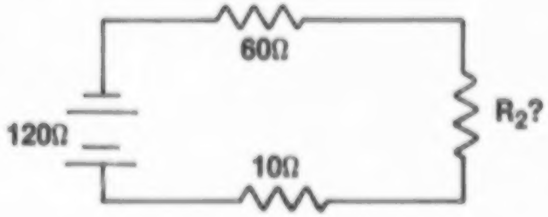
1.



R_1?
R_t 60Ω
25Ω
20Ω

Answer ____________

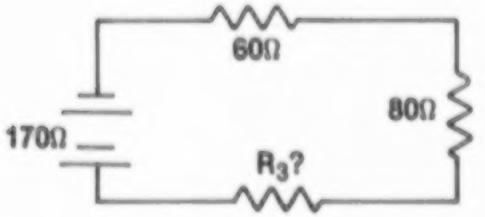
2.



60Ω
120Ω
R_2?
10Ω

Answer ____________

3.

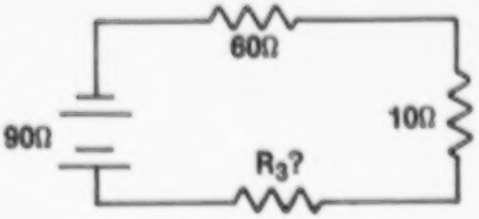


60Ω
170Ω
80Ω
R_3?

Answer ____________

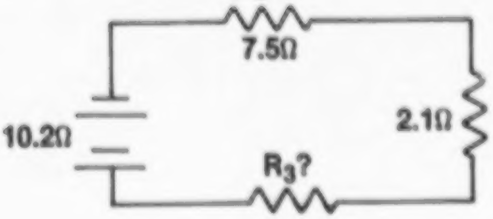
ASSIGNMENT SHEET #5

4.


60Ω
90Ω
10Ω
R_3?

Answer ____________________

5.


7.5Ω
10.2Ω
2.1Ω
R_3?

Answer ____________________

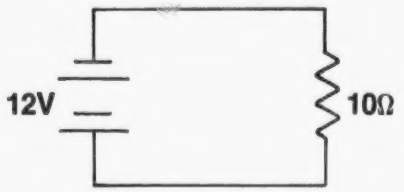
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #6 — SOLVE PROBLEMS FOR UNKNOWN CURRENT IN A SERIES CIRCUIT

NAME ______________________________ SCORE ______________

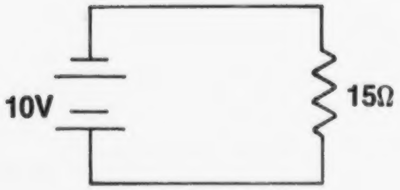
Directions: Apply the appropriate formulas to find the current in the following problems. Show calculations in the space provided above each answer.

1.



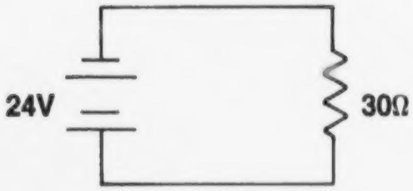
Answer ______________

2.



Answer ______________

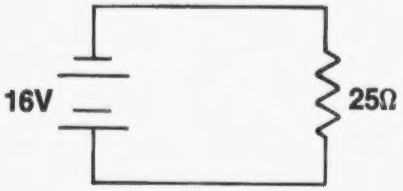
3.



Answer ______________

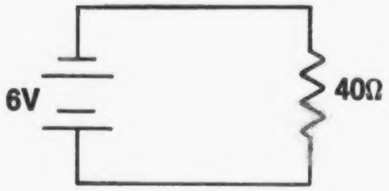
ASSIGNMENT SHEET #6

4.



Answer ____________________

5.



Answer ____________________

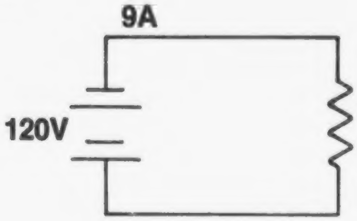
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #7 — SOLVE PROBLEMS FOR UNKNOWN RESISTANCE IN A SERIES CIRCUIT

NAME ________________________________ SCORE ______________

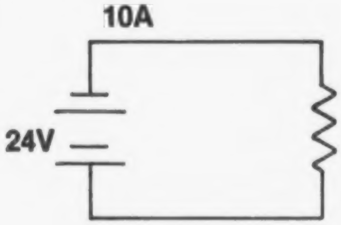
Directions: Apply the appropriate formula to find resistance in the following series circuits. Show calculations in the space provided above each answer.

1.



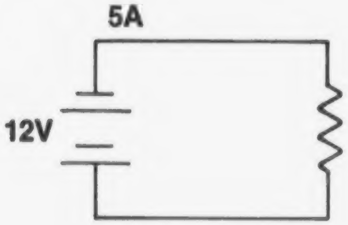
Answer ______________

2.



Answer ______________

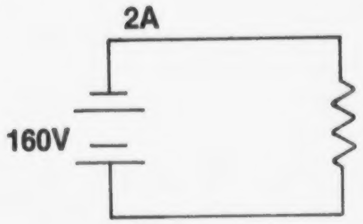
3.



Answer ______________

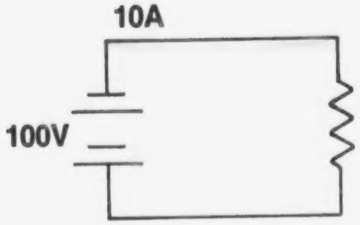
ASSIGNMENT SHEET #7

4.



Answer ____________________

5.



Answer ____________________

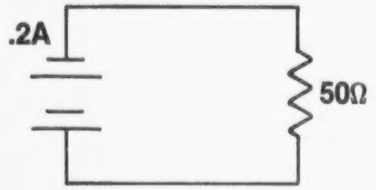
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #8 — SOLVE PROBLEMS FOR UNKNOWN VOLTAGE IN A SERIES CIRCUIT

NAME ______________________________ SCORE ______________

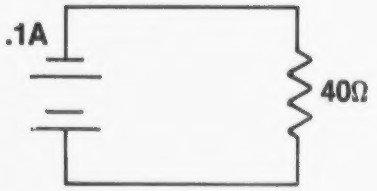
Directions: Apply the appropriate formula to find voltage in the following series circuits. Show calculations in the space provided above each answer.

1.



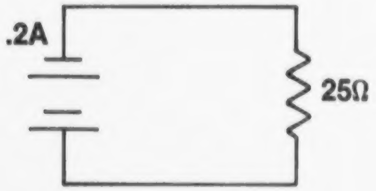
Answer ______________

2.



Answer ______________

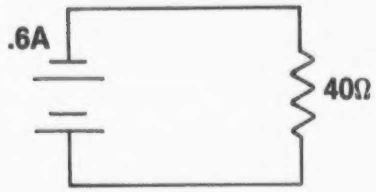
3.



Answer ______________

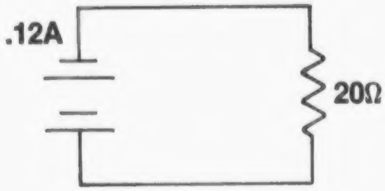
ASSIGNMENT SHEET #8

4.



Answer ____________________

5.



Answer ____________________

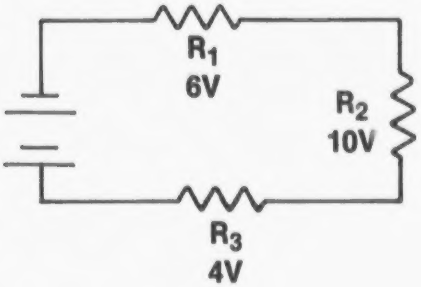
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #9 — APPLY KIRCHOFF'S VOLTAGE LAW TO SERIES CIRCUITS

NAME ____ SCORE ________________

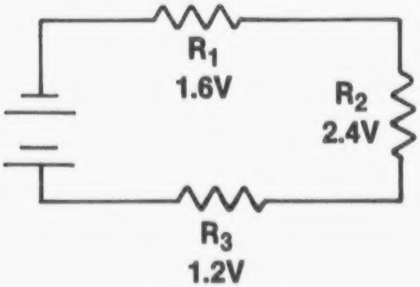
Directions: Using Kirchoff's voltage law, find voltage in the following problems. Show calculations in the space provided above each answer.

1.


R_1
6V
R_2
10V
R_3
4V

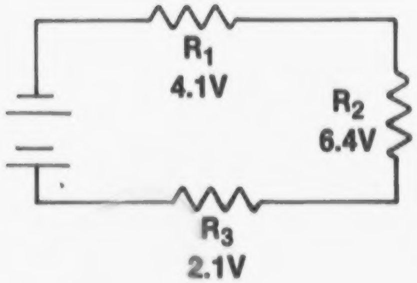
Answer ________________

2.


R_1
1.6V
R_2
2.4V
R_3
1.2V

Answer ________________

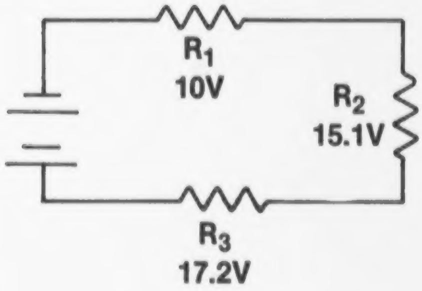
3.


R_1
4.1V
R_2
6.4V
R_3
2.1V

Answer ________________

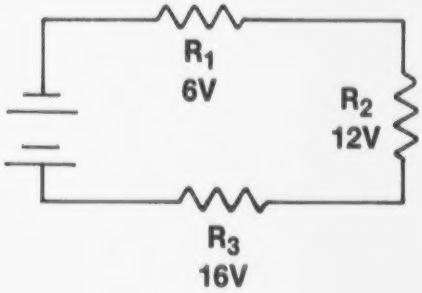
ASSIGNMENT SHEET #9

4.


R1
10V
R2
15.1V
R3
17.2V

Answer ______________________

5.


R1
6V
R2
12V
R3
16V

Answer ______________________

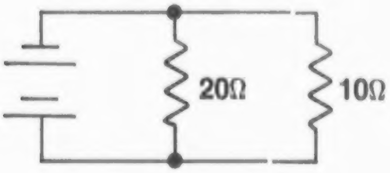
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #10 — SOLVE PROBLEMS FOR UNKNOWN RESISTORS IN A PARALLEL CIRCUIT

NAME ______________________ SCORE ______________

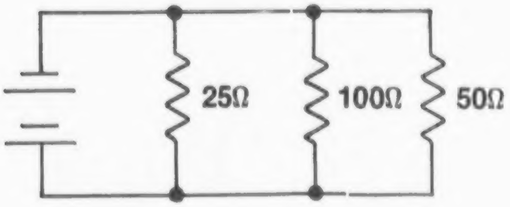
Directions: Apply the appropriate formula to find resistance in the following problems. Show calculations in the space provided above each answer.

1.



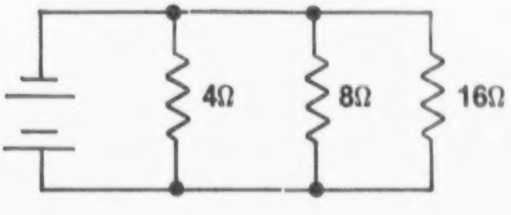
Answer ______________

2.



Answer ______________

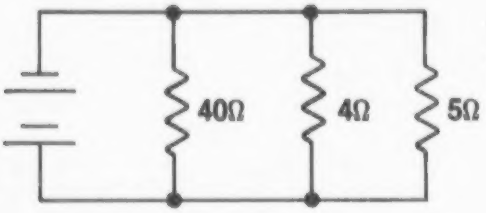
3.



Answer ______________

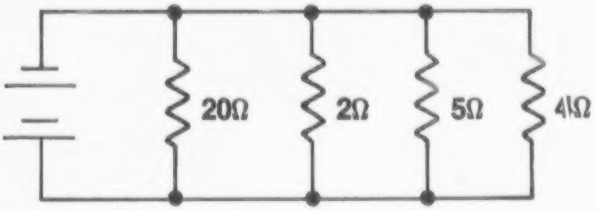
ASSIGNMENT SHEET #10

4.



Answer ____________________

5.



Answer ____________________

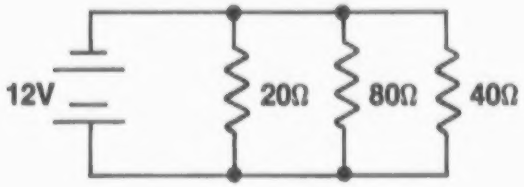
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #11 — SOLVE PROBLEMS FOR UNKNOWN CURRENT IN A PARALLEL CIRCUIT

NAME ______________________ SCORE ____________

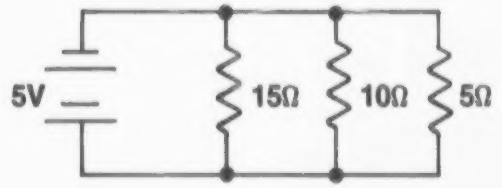
Directions: Apply the appropriate formula to find current in the following problems. Show calculations in the space provided above each answer.

1.


12V
20Ω
80Ω
40Ω

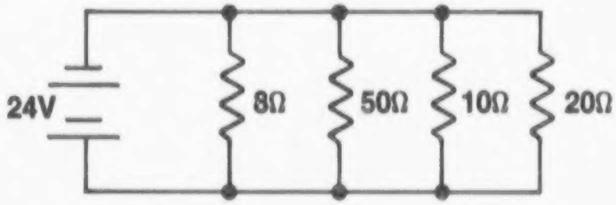
Answer ____________

2.


5V
15Ω
10Ω
5Ω

Answer ____________

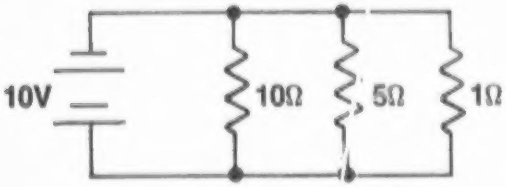
3.


24V
8Ω
50Ω
10Ω
20Ω

Answer ____________

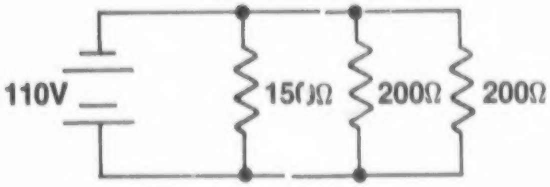
ASSIGNMENT SHEET #11

4.


10V
10Ω
5Ω
1Ω

Answer ____________________

5.


110V
150Ω
200Ω
200Ω

Answer ____________________

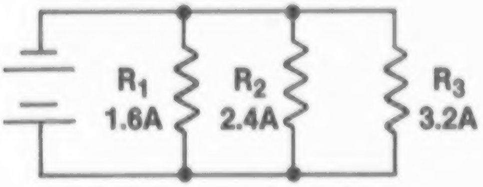
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #12 — APPLY KIRCHOFF'S CURRENT LAW TO PARALLEL CIRCUITS

NAME ______________________________ SCORE ______________

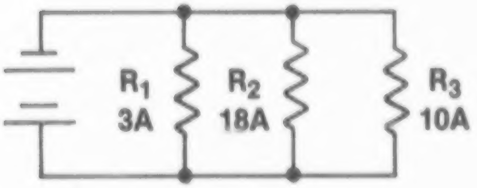
Directions: Using Kirchoff's current law, find current in the following problems. Show calculations in the space provided above each answer.

1.


R_1
1.6A
R_2
2.4A
R_3
3.2A

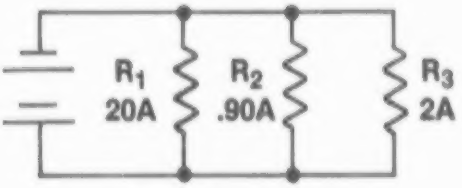
Answer ______________

2.


R_1
3A
R_2
18A
R_3
10A

Answer ______________

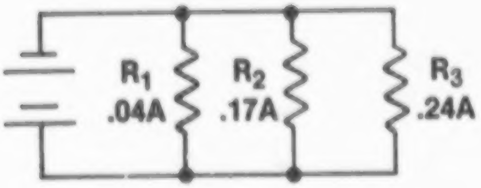
3.


R_1
20A
R_2
.90A
R_3
2A

Answer ______________

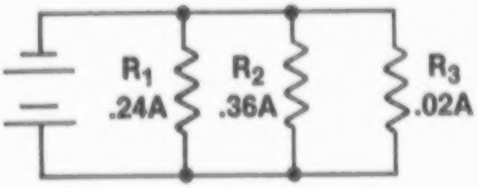
ASSIGNMENT SHEET #12

4.


R_1
.04A
R_2
.17A
R_3
.24A

Answer ________________

5.


R_1
.24A
R_2
.36A
R_3
.02A

Answer ________________

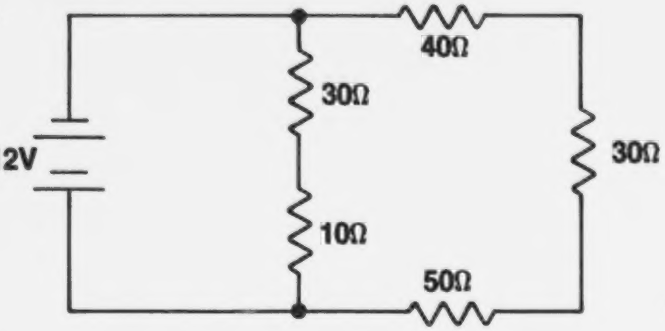
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #13 — SOLVE PROBLEMS FOR UNKNOWN RESISTANCE IN A SERIES-PARALLEL CIRCUIT

NAME ______________________________ SCORE ____________

Directions: Apply the appropriate formula to find resistance in the following problems. Show calculations in the space provided above each answer.

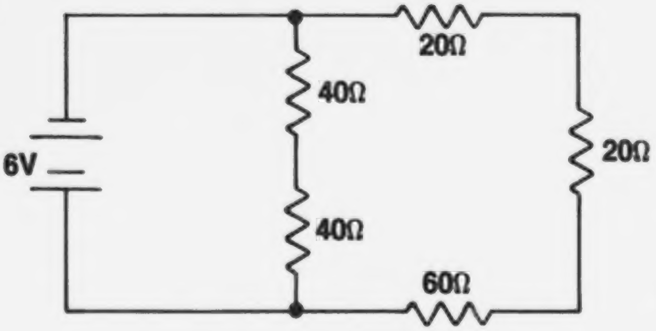
1.



40Ω
30Ω
12V
30Ω
10Ω
50Ω

Answer ____________

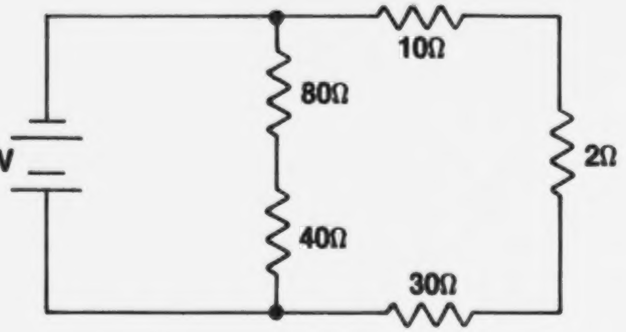
2.



20Ω
40Ω
6V
20Ω
40Ω
60Ω

Answer ____________

3.



10Ω
80Ω
24V
2Ω
40Ω
30Ω

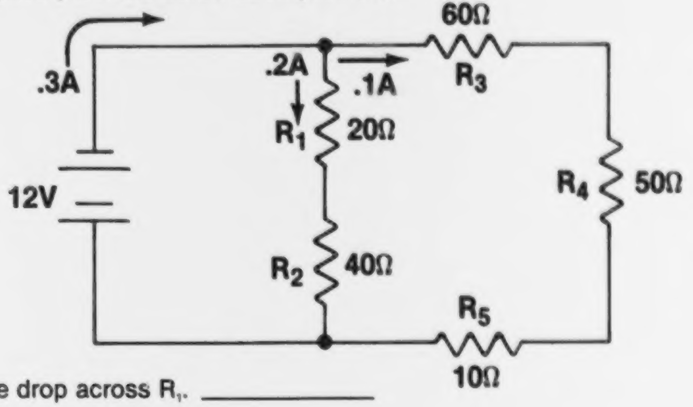
Answer ____________

DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #14 — SOLVE PROBLEMS FOR UNKNOWN VOLTAGE IN A SERIES-PARALLEL CIRCUIT

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula to find voltage in the following problems. Show calculations in the space provided below each problem.



1. Find voltage drop across R_1. ______________

2. Find voltage drop across R_2. ______________

3. Find voltage drop across R_3. ______________

4. Find voltage drop across R_4. ______________

5. Find voltage drop across R_5. ______________

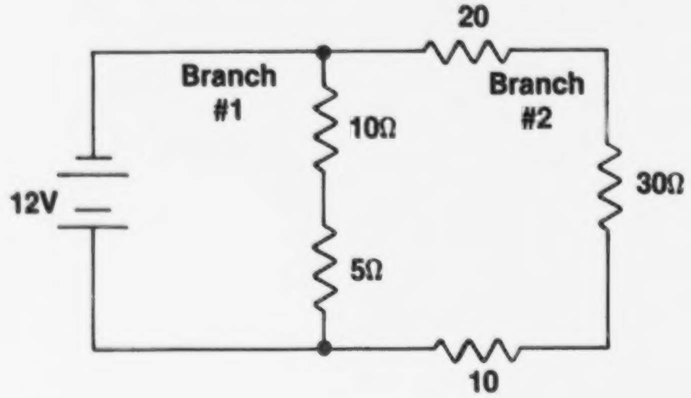
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #15 — SOLVE PROBLEMS FOR UNKNOWN CURRENT IN A SERIES-PARALLEL CIRCUIT

NAME ______________________________ SCORE ______________

Directions: Apply the appropriate formula to find current in the following problems. Show your calculations.

A.


20
Branch #1
10Ω
Branch #2
30Ω
12V
5Ω
10

1. Total current ______________

2. Total current ______________

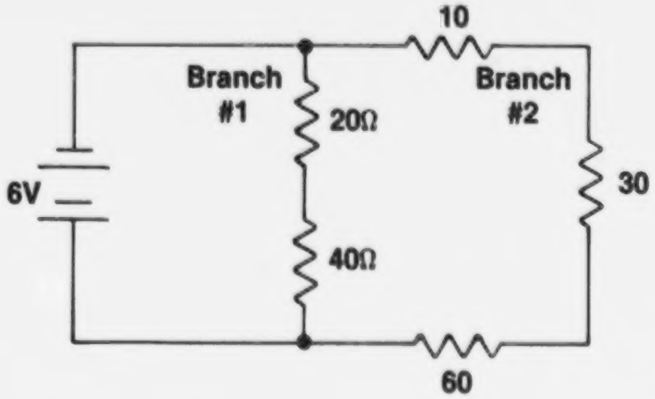
   Branch #1 ______________

3. Total current

   Branch #2 ______________

ASSIGNMENT SHEET #15

B.


10
Branch #1
20Ω
Branch #2
6V
30
40Ω
60

1. Total current ________________

2. Total current ________________

Branch #1 ________________

3. Total current ________________

Branch #2 ________________

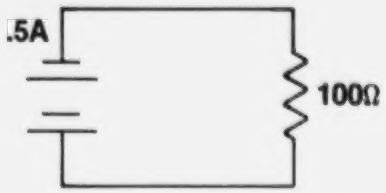
DC CIRCUITS
UNIT IX

ASSIGNMENT SHEET #16 — COMPUTE POWER USING OHM'S POWER LAW

NAME ______________________________ SCORE ____________

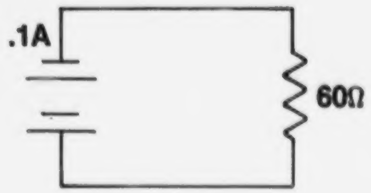
Directions: Apply Ohm's power law to determine power in the following problems. Show calculations in the space provided above each answer.

1.



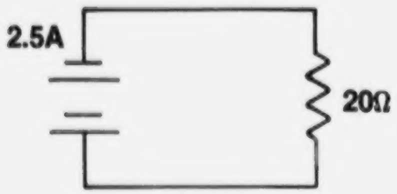
Answer ____________

2.



Answer ____________

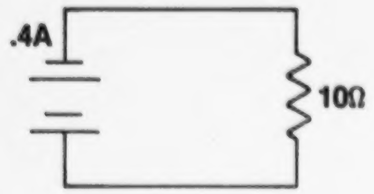
3.



Answer ____________

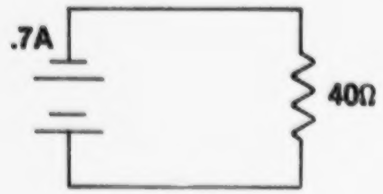
ASSIGNMENT SHEET #16

4.



Answer ______________

5.



Answer ______________

DC CIRCUITS
UNIT IX

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. .25A
2. .8A
3. .6A
4. 2A
5. .89A

Assignment Sheet #2

1. 6Ω
2. 6Ω
3. 24Ω
4. 20Ω
5. 80Ω

Assignment Sheet #3

1. 500V
2. 800V
3. 1200V
4. 2800V
5. 800V

Assignment Sheet #4

1. 85Ω
2. 155Ω
3. 280Ω
4. 200Ω
5. 115Ω

Assignment Sheet #5

1. 15Ω
2. 50Ω
3. 30Ω
4. 20Ω
5. .6Ω

Assignment Sheet #6

1. 1.2
2. .66
3. .46
4. .64
5. .15

Assignment Sheet #7

1. 13.33Ω
2. 2.4Ω
3. 2.4Ω
4. 8Ω
5. 10Ω

Assignment Sheet #8

1. 10V
2. 4V
3. 5V
4. 24V
5. 2.4V

Assignment Sheet #9

1. 20V
2. 5.2V
3. 12.6V
4. 42.3V
5. 34V

Assignment Sheet #10

1. 6.66Ω
2. 14.29Ω
3. 28.86Ω
4. 2.11Ω
5. 1Ω

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #11

1. 11.42A
2. 2.72A
3. 3.38A
4. .76A
5. 60A

Assignment Sheet #12

1. 7.2A
2. 31A
3. 112A
4. .45A
5. .62A

Assignment Sheet #13

1. 40Ω
2. 44.44Ω
3. 31.11Ω

Assignment Sheet #14

1. 8V
2. 4V
3. 5V
4. 6V
5. 1V

Assignment Sheet #15

A. 1. Total — 1A
   2. Branch #1 — .8A
   3. Branch #2 — .2A
B. 1. Total — .16A
   2. Branch #1 — .1A
   3. Branch #2 — .06A

Assignment Sheet #16

1. .25Ω
2. .6Ω
3. 1250Ω
4. 1.6Ω
5. 19.6Ω

DC CIRCUITS
UNIT IX

TEST

NAME ____ SCORE ________________

1. Match the terms on the right with their correct definitions.

_____a. A mathematical expression used to find unknowns

_____b. A complete path for current to flow from the source through the load and back to the source

_____c. Reduction in circuit potential difference due to resistance

_____d. Opposition to electron flow in a conductor or circuit

_____e. Power around a magnet

_____f. Molecules that act as small magnets when arranged end to end

_____g. Measurement of the rate of flow of current through a conductor

_____h. Abbreviation for direct current

_____i. Materials which permit the free flow of electrons

_____j. The measurement of the potential difference between conductors in a circuit

_____k. When magnetism leaves a body north and enters south

_____l. A circuit that contains some components in series and some in parallel

_____m. Rate of consumption of energy

_____n. A magnet made by winding a conductor around a metal core with voltage applied

1. Amperage
2. Circuit
3. Conductors
4. DC
5. Domains
6. Electromagnet
7. Flux lines
8. Formula
9. Magnetism
10. Parallel circuit
11. Polarity
12. Power
13. Resistance
14. Series circuit
15. Series-parallel circuit
16. Voltage
17. Voltage drop

TEST

_____o. Property possessed by certain materials which exerts a mechanical force on other magnetic materials, and which can cause induced voltage in conductors when relative movement is present

_____p. A circuit which provides more than one path for current to flow

_____q. A circuit where the same current passes through each component

2. List six applications of DC circuits.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

3. State the application of Ohm's law to DC.

____

____

____

4. Select true statements concerning characteristics of series circuits by placing an "X" in the blanks preceding the true statements.

_____a. A series circuit will only let current flow one way. The components are connected end to end forming a continuous loop going back to the power source.

_____b. A combination of resistors in series is called serialization.

_____c. When current travels through a resistor, the voltage drop across each resistor is equal to the current divided by the resistance ($E = I/R$).

_____d. In a series circuit, the formula ($R_1 = R_t - R_2 - R_3$) may be used to find an individual resistance if the total resistance and the resistances of the other components are known.

TEST

5. Complete the three basic formulas for Watt's law by inserting the letters, numbers, and words which best complete each formula.

   a. P (in watts) = E (volts) × ____________

   b. P (in watts) = ____________ × R (ohms)

   c. P (in watts) = $\frac{E^2 \text{ (volts)}}{\rule{2cm}{0.4pt}}$

6. State Kirchoff's voltage law.

   ____

   ____

7. Select true statements concerning characteristics of parallel circuits by placing an "X" in the blanks preceding the true statements.

   _____a. A parallel circuit has only one path of current flow and carries the load across two branch circuits.

   _____b. Voltage drop in a parallel circuit is the drop over the entire circuit; the voltage remains the same throughout the entire system.

   _____c. Total resistance in a parallel circuit is always more than any branch resistance.

   _____d. Reciprocals are any fraction turned upside down.

   _____e. When voltage and the resistance of each branch are known, the branch currents may be calculated by Ohm's law.

8. State Kirchoff's current law.

   ____

   ____

   ____

TEST

9. Complete the following statements concerning characteristics of series-parallel circuits by inserting the words that best complete each statement.

   a. A series-parallel circuit is a circuit used with both series circuits and parallel circuits __________________.

   b. Step 1 in finding resistance in series-parallel circuits is to calculate the total resistance for the circuit and add together the __________________ in each branch.

   c. Step 2 is to __________________ the circuit to use only one resistance in each branch.

   d. The resistance for the circuit may now be calculated by combining the __________________ resistances.

10. Select true statements concerning facts about magnetism by placing an "X" in the blanks preceding the true statements.

    _____a. There are three basic kinds of magnets.

    _____b. Electromagnets are made from rocks and minerals.

    _____c. A magnet is composed of lines of power around the magnetic field called domains.

    _____d. Magnetic flux lines have four magnetic fields.

    _____e. When the north pole is put to the south pole, they repel.

    _____f. Current flow in a conductor produces magnetic lines of force around the conductor.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

11. Solve problems for an unknown current. (Assignment Sheet #1)

12. Solve problems for an unknown resistance. (Assignment Sheet #2)

13. Solve problems for an unknown voltage. (Assignment Sheet #3)

14. Determine the total resistance in a series circuit. (Assignment Sheet #4)

15. Determine unknown resistor values in a series circuit. (Assignment Sheet #5)

16. Solve problems for unknown current in a series circuit. (Assignment Sheet #6)

17. Solve problems for unknown resistance in a series circuit. (Assignment Sheet #7)

TEST

18. Solve problems for unknown voltage in a series circuit. (Assignment Sheet #8)

19. Apply Kirchoff's voltage law to series circuits. (Assignment Sheet #9)

20. Solve problems for unknown resistance in a parallel circuit. (Assignment Sheet #10)

21. Solve problems for unknown current in a parallel circuit. (Assignment Sheet #11)

22. Apply Kirchoff's current law to parallel circuits. (Assignment Sheet #12)

23. Solve problems for unknown resistance in a series-parallel circuit. (Assignment Sheet #13)

24. Solve problems for unknown voltage in a series-parallel circuit. (Assignment Sheet #14)

25. Solve problems for unknown current in a series-parallel circuit. (Assignment Sheet #15)

26. Compute power using Ohm's power law. (Assignment Sheet #16)

DC CIRCUITS
UNIT IX

ANSWERS TO TEST

1. a. 8
   b. 2
   c. 17
   d. 13
   e. 7
   f. 5
   g. 1
   h. 4
   i. 3
   j. 16
   k. 11
   l. 15
   m. 12
   n. 6
   o. 9
   p. 10
   q. 14

2. Any six of the following:

   a. Industrial locations for controls and power
   b. Moving of materials and parts
   c. Home appliances, radio, television, and stereo equipment
   d. Automobile and truck systems
   e. Telephone and communications circuits
   f. Computers and electronic equipment
   g. Airplanes for control and power systems
   h. Medical field
   i. Power for electric carts and battery charges

3. Ohm's law may be used for computing current, resistance, and voltage. Formulas are expressed as:

   Current (I) = E/R
   Resistance (R) = E/I
   Voltage (E) = $I \times R$

4. a, d

5. a. I (amperes)
   b. I^2 (amperes)
   c. R (ohms)

6. The sum of the individual voltage drops in a series circuit is equal to the applied voltage.

7. b, d, e

8. The sum of the currents through the individual branches of a parallel circuit is equal to the total current of the circuit.

ANSWERS TO TEST

9. a. Connected
   b. Series resistances
   c. Redraw
   d. Parallel

10. d, f

11.-26. Evaluated to the satisfaction of the instructor

AC CIRCUITS
UNIT X

UNIT OBJECTIVE

After completion of this unit, the student should be able to construct and wire single, three-way and four-way switches in a circuit. Competencies will be demonstrated by completing the assignment sheets, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to AC circuits with their correct definitions.
2. Select true statements concerning principles of AC theory.
3. Complete statements related to the principles of induction.
4. Complete statements related to the characteristics of inductance.
5. Select true statements concerning factors affecting inductors.
6. Select true statements related to power characteristics in an inductive circuit.
7. Complete statements concerning characteristics of a transformer.
8. List two classes of transformers.
9. Identify transformer connections on a three-phase delta system.
10. Identify other transformer connections found in electrical trades.
11. Complete statements concerning power in three-phase circuits.
12. Select true statements concerning testing for polarity.

OBJECTIVE SHEET

13. Complete statements related to characteristics of capacitance.

14. Select true statements concerning types, ratings, and common defects of capacitors.

15. Complete equations related to the characteristics of impedance in RC circuits.

16. Complete statements related to characteristics of impedance in RL circuits.

17. Select true statements concerning characteristics of power in an AC circuit.

18. List three basic switching circuits used in electricity.

19. Solve power factor problems. (Assignment Sheet #1)

20. Solve RC and RL circuit problems. (Assignment Sheet #2)

21. Draw a diagram of a single pole switch on a light. (Assignment Sheet #3)

22. Draw a diagram of two three-way switches on a light. (Assignment Sheet #4)

23. Draw a diagram of two three-way switches and a four-way switch on a light. (Assignment Sheet #5)

24. Demonstrate the ability to:

    a. Wire a single pole switch controlling a single lighting outlet with the supply line entering the switch box. (Job Sheet #1)

    b. Wire a single pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box. (Job Sheet #2)

    c. Wire a three-way switching situation with the supply entering a single lighting outlet. (Job Sheet #3)

    d. Wire a four-way switching situation with the supply entering the lighting outlet box. (Job Sheet #4)

AC CIRCUITS
UNIT X

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Have students view an AC waveform on an oscilloscope.
2. Show a film about AC circuits.
3. Take a field trip to a house under construction and view basic switching devices.
4. Invite a representative from a local supply house to give a demonstration on switching.
5. Show students how to solve RC and RL circuit problems. Discuss calculations in class. Assignment Sheet #2 should be completed following this lesson.
6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. Adams, James E. and Gorden Rockmaker. *Industrial Electricity Principles and Practices*. Third Edition. New York: McGraw-Hill Book Company, 1985.

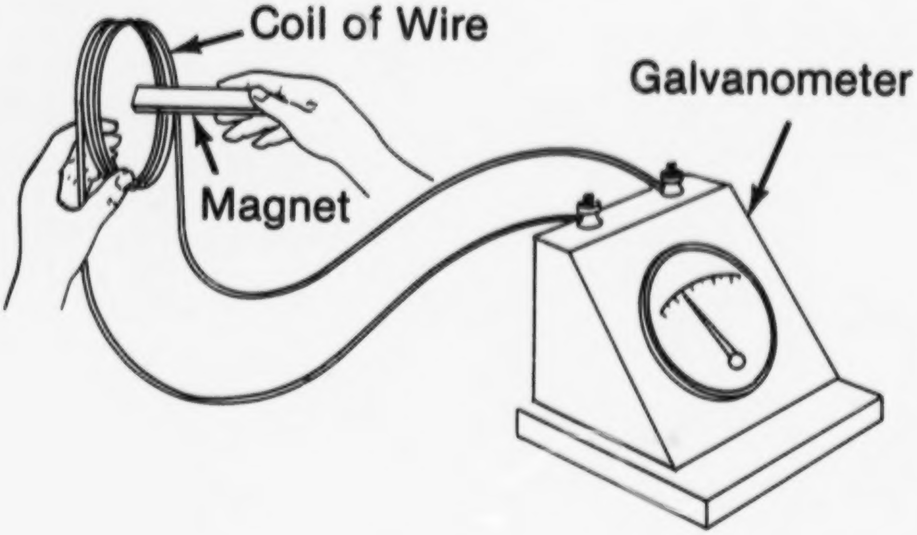
B. *Basic Electricity Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1985.

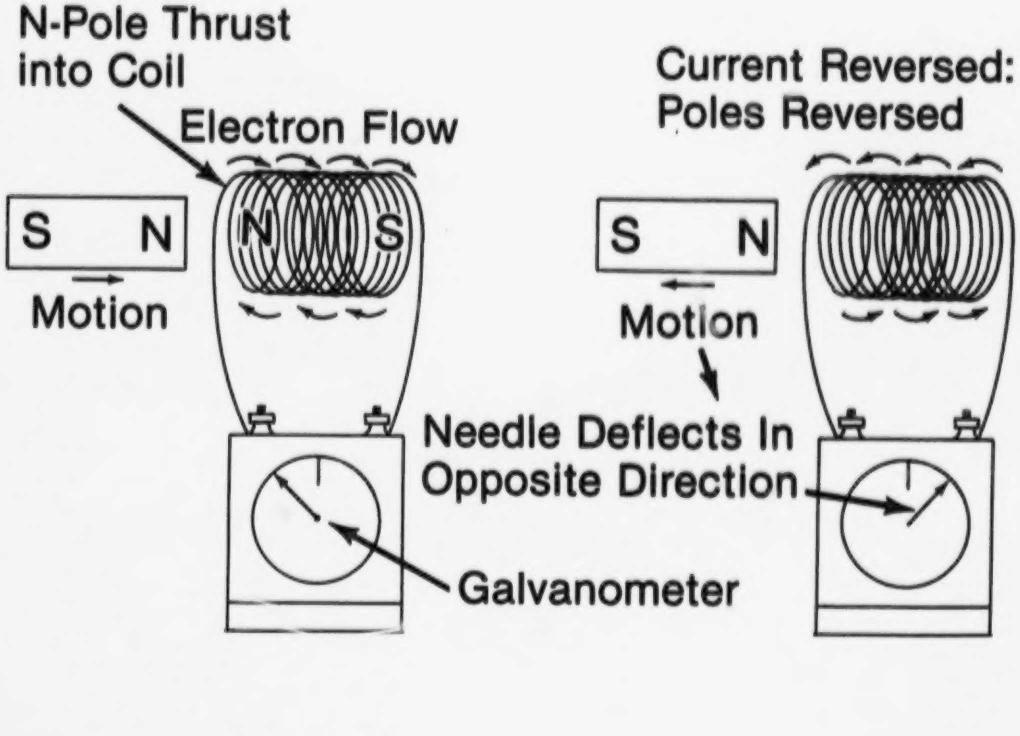
C. Vorderstrasse, Ron. *General Electronics Technician*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

SUGGESTED SUPPLEMENTAL MATERIAL

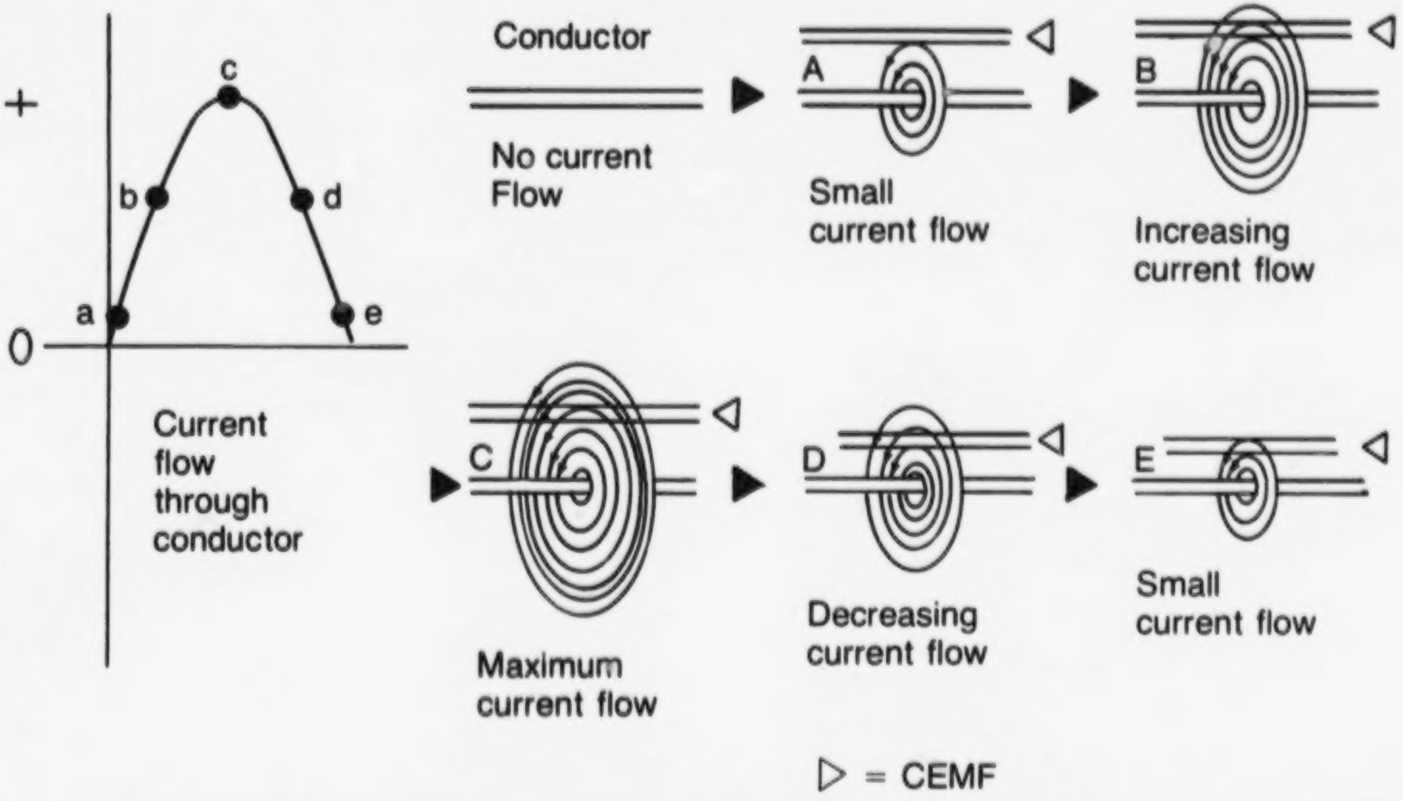
Film — *Basic Electricity Review*. NUS Training Corporation, 1350 Piccard Drive, Rockville, MD 20850.

Induced Current


Coil of Wire
Galvanometer
Magnet


N-Pole Thrust into Coil
Electron Flow
S
N
Motion
N
S
Galvanometer
Current Reversed: Poles Reversed
S
N
Motion
Needle Deflects In Opposite Direction

Induction


+
0
a
b
c
d
e
Current flow through conductor
Conductor
No current Flow
A
Small current flow
B
Increasing current flow
C
Maximum current flow
D
Decreasing current flow
E
Small current flow
▷ = CEMF

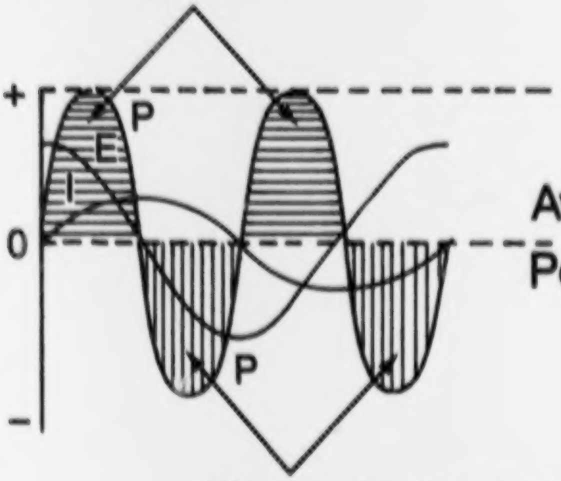
Relationship of magnetic field around a wire to current flowing through the wire.

TM 2
Objective IV

BW-539

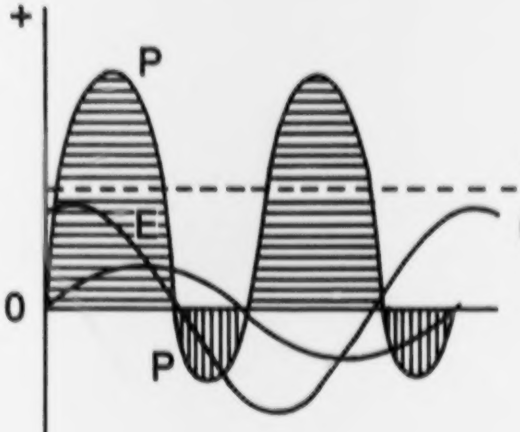
Power in RL Circuits

Power Consumed by the Inductor



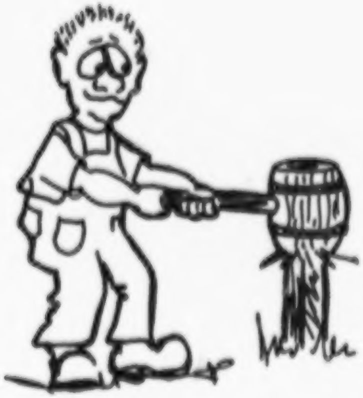
Average Power - Zero

Power Returned to the Circuit by the Inductor

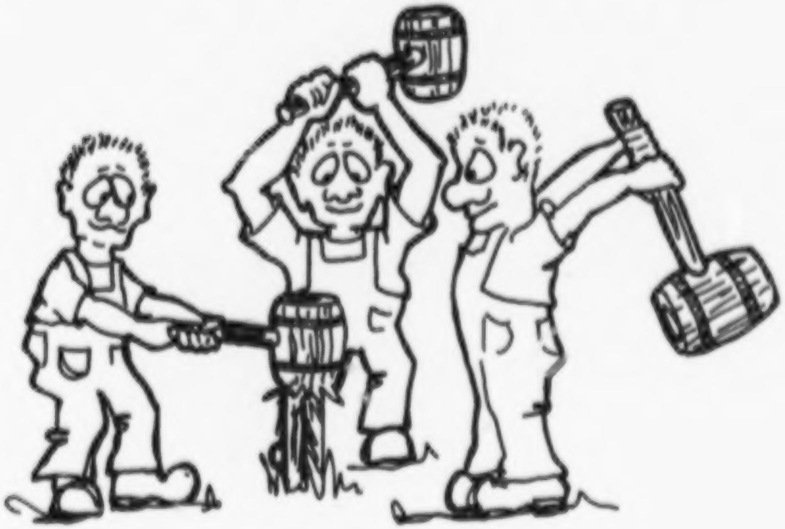


Average (True) Power

Classes of Transformers



Single Phase

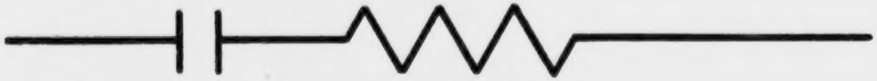


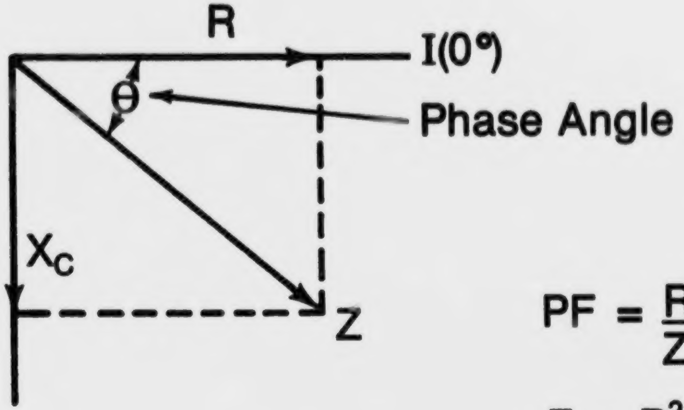
Three Phase

TM 4
Objective VIII

BW-543

Impedance Relationships in an RC Circuit

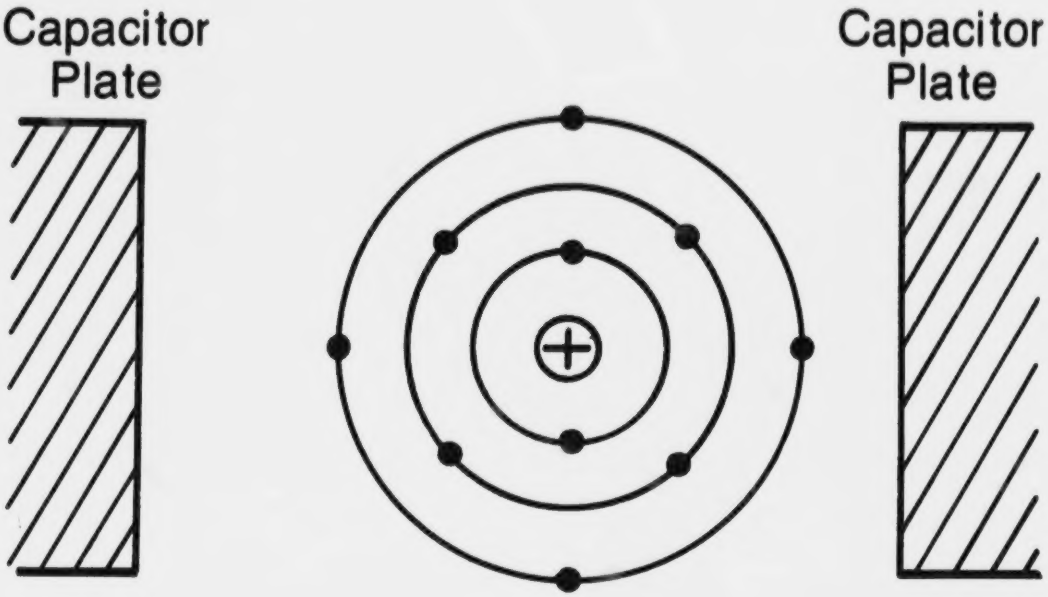



R
I(0°)
θ
Phase Angle
X_C
Z

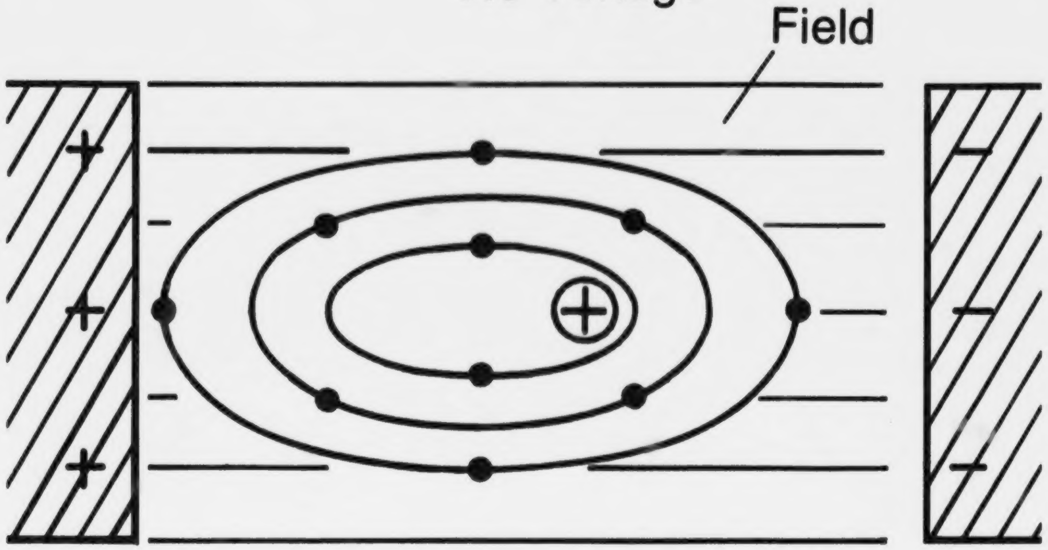
$$PF = \frac{R}{Z}$$

$$Z = R^2 + X_C^2$$

Electric Field Effect on Dielectrics


Capacitor Plate
Capacitor Plate

No Voltage



Voltage Applied

Capacitor Construction

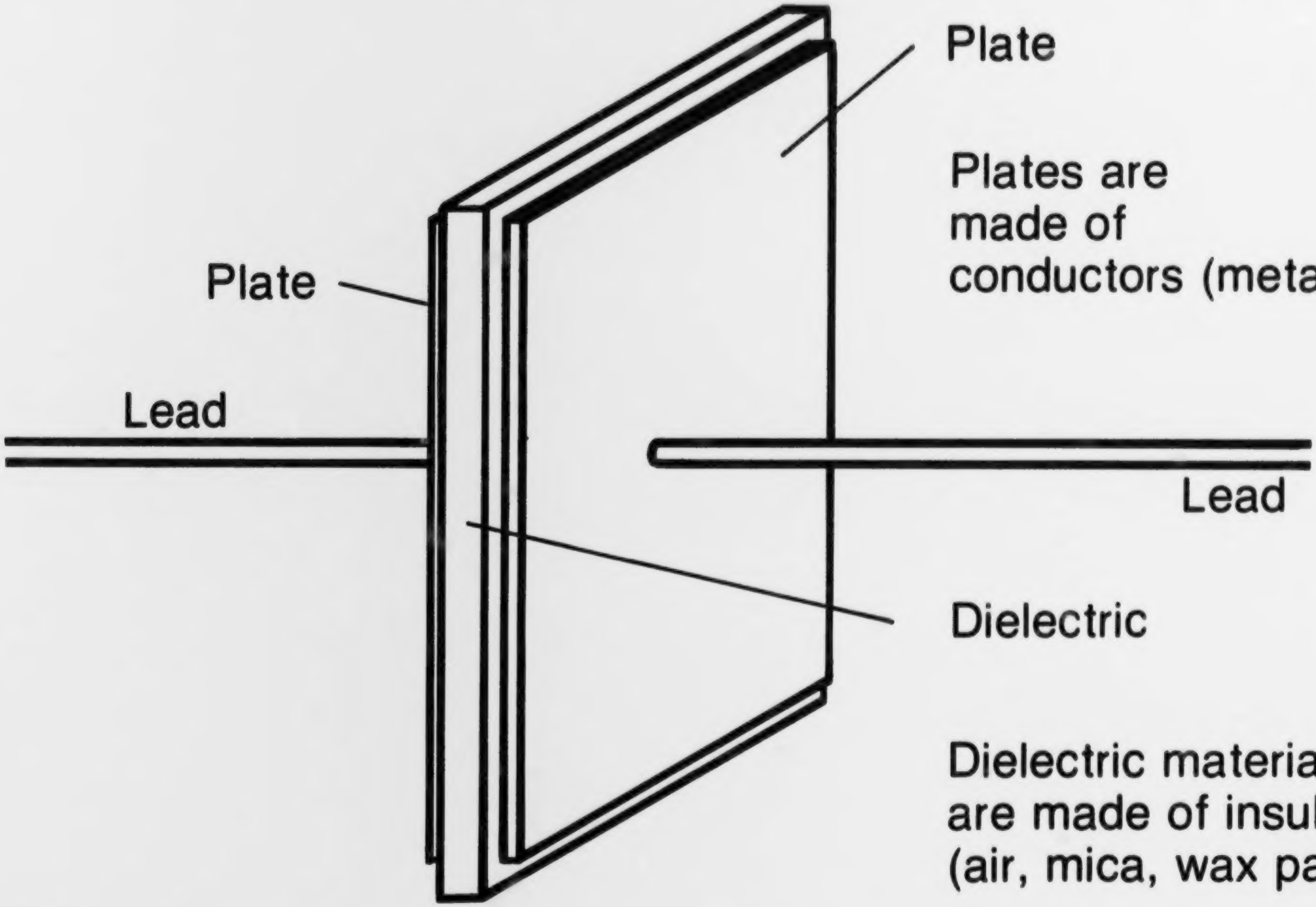
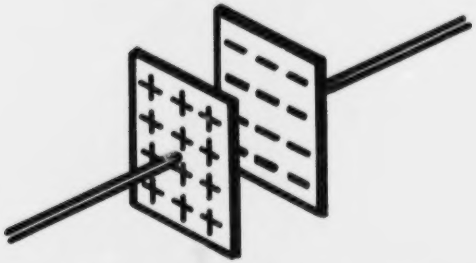


Plate
Plate
Lead
Lead
Dielectric

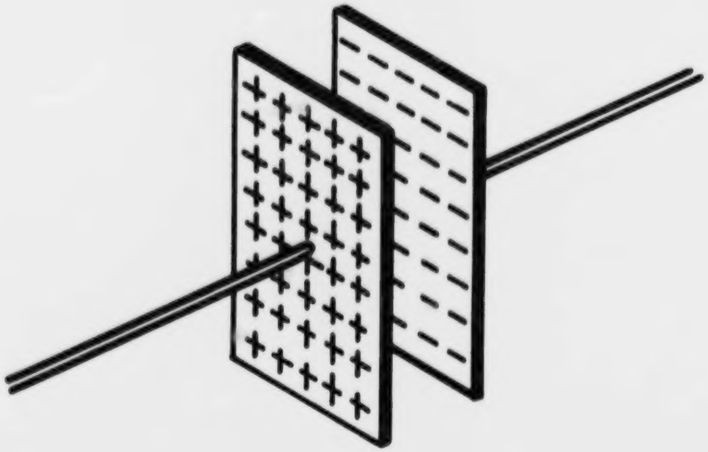
Plates are
made of
conductors (metals)

Dielectric materials
are made of insulators
(air, mica, wax paper)

Plate Area



Larger plates hold more electrons.



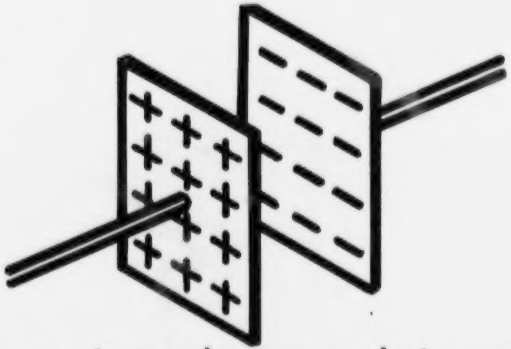
Increased plate area increases capacitance.

Objective XV

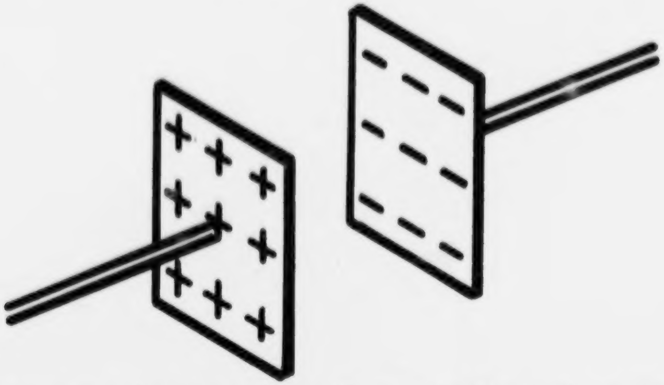
TM 8

BW-551

Plate Distance



The distance between two charges determines their effect on one another.



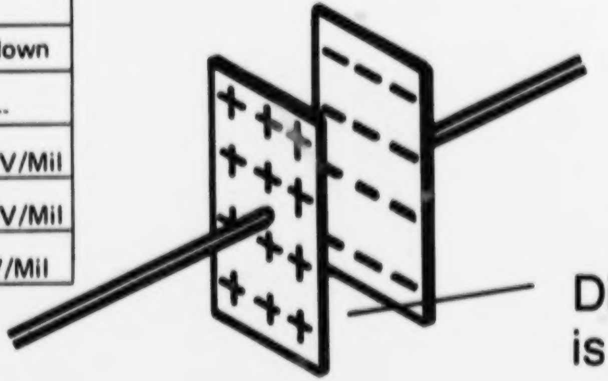
Increasing the distance between the plates decreases capacitance.

Objective XV
TM 9

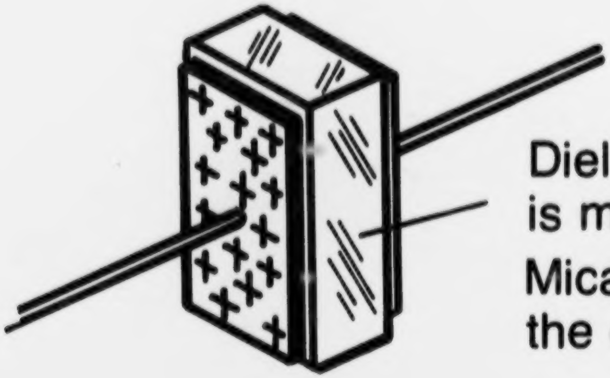
BW-553

Effect of the Dielectric

Typical Dielectrics		
Type	Constant	Breakdown
Air	1.0	-----
Mica	5.4	5000V/Mil
Teflon	2.1	1500V/Mil
Paper	3.0	200V/Mil



Dielectrical material is air.

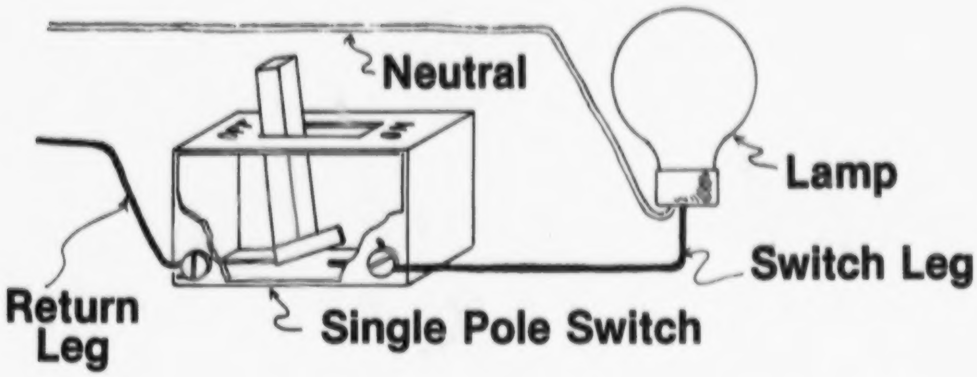


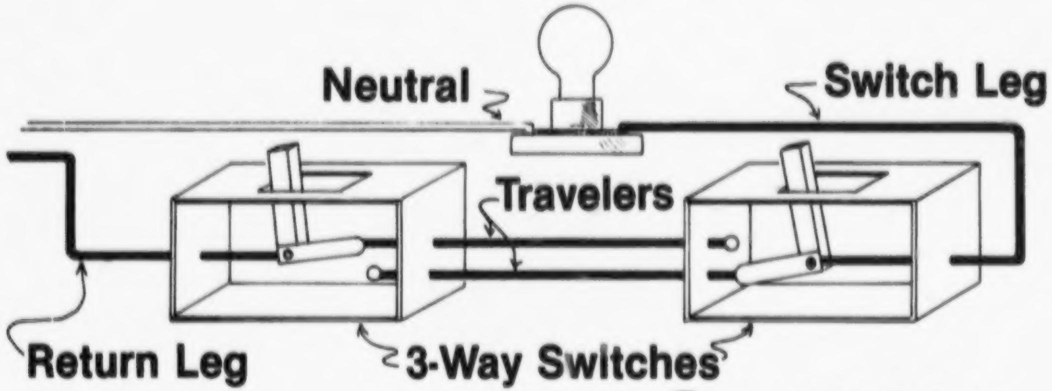
Dielectrical material is mica.

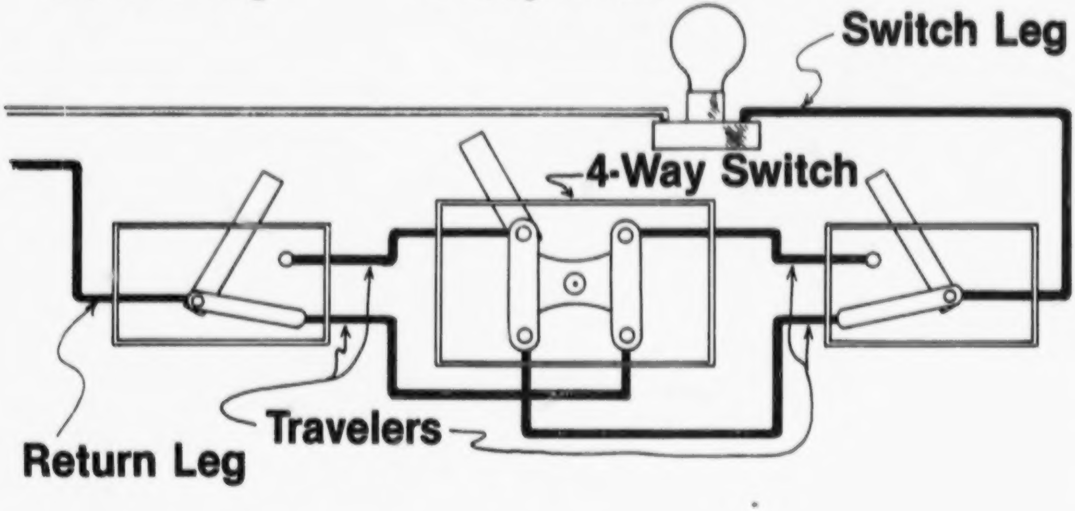
Mica dielectric increases the capacitance.

Changing the dielectric material changes the capacitance.

AC Switching Circuits


Neutral
Lamp
Switch Leg
Return Leg
Single Pole Switch


Neutral
Switch Leg
Travelers
Return Leg
3-Way Switches


Switch Leg
4-Way Switch
Travelers
Return Leg

AC CIRCUITS
UNIT X

INFORMATION SHEET

I. Terms and definitions

A. Apparent power — Term used to describe the power which "appears" to be consumed in an RC circuit when the power formula $P = IE$ is applied to the circuit

B. Autotransformer — Transformer with a single winding

C. Connections — Termination points where conductors are joined together

D. Dielectric materials — Insulating materials capable of accumulating an electrical charge

E. Henry — Amount of inductance into a conductor when the current changes at the rate of one ampere per second

F. Opposition — A resistance to current flow

G. Primary — Where voltage enters a transformer

H. Secondary — Where voltage leaves a transformer

I. Single phase — One power source

J. True power — The power that a device is actually using

K. Waveform — The shape of a wave as a function of time, distance, and amplitude

L. Windings — Conductors coiled around a metal core in a transformer or motor

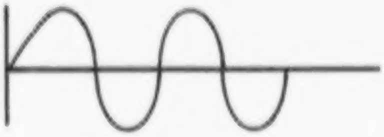
II. Principles of AC theory

A. AC current flows in two directions; it flows in one direction, stops, and then flows in the opposite direction.

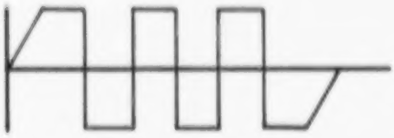
INFORMATION SHEET

B. There are three basic types of waveforms: sine wave, square wave, and sawtooth wave.

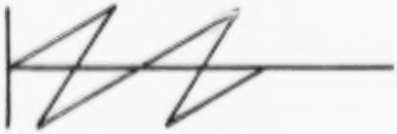
EXAMPLES:



Sine Wave



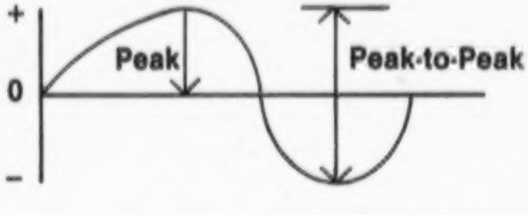
Square Wave



Sawtooth Wave

C. Sine waves are measured peak-to-peak in AC voltage or amperes.

EXAMPLE:



D. Peak-to-peak current and voltages occur twice in a cycle: one in the positive direction and one in the negative direction.

E. The rms (root-mean-square) or effective value of the sine wave is 0.707 times peak value.

F. Electromotive force (emf) causes current to flow through a device; this is referred to in sine waves as V.

INFORMATION SHEET

III. Principles of Induction

A. Magnetic induction occurs when a magnet is placed in close proximity to a ferromagnetic material causing the material to also become magnetized.

B. Electromagnetic induction is the action which causes electrons to flow in a conductor when the conductor cuts the lines of force in a magnetic field.

C. The amount of current induced into the conductor is determined by four factors (Faraday's law):

1. **Strength** of the magnetic field
2. **Speed** of the conductor with respect to the field
3. **Angle** at which the conductor cuts the field
4. **Length** of the conductor in the field

D. Lenz' law states simply that the direction of the induced current must be such that its own magnetic field will oppose the action that produced the induced current.

IV. Characteristics of Inductance

A. Inductance is the physical property of a circuit or device which indicates an ability to oppose a change in current.

B. Inductance may also be defined as the ability to induce an EMF into a conductor when there is a change in current flow.

C. The symbol for inductance is the letter L.

D. The unit of measurement for inductance is the Henry.

1. A Henry is the amount of inductance that induces an EMF of one volt into a conductor when the current changes at the rate of one ampere per second.
2. The Henry is expressed symbolically with the letter "H".

   (NOTE: The Henry is a relatively large unit, therefore the millihenry (mH) and the microhenry (uH) are the units generally used in practice.)

INFORMATION SHEET

V. Factors affecting inductors

A. An inductor is a physical device consisting of a coil of wire usually wound on a core.

(NOTE: An inductor may also be called a coil or choke.)

B. The inductance of a coil varies as the square of the number of turns.

C. Inductance of a coil may be increased dramatically by winding the coil on a core of material that has a high permeability.

D. Inductance varies inversely with the length of the coil.

VI. Power characteristics in an inductive circuit

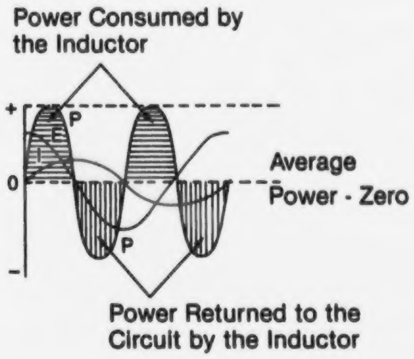
A. No power is dissipated in a pure inductance.

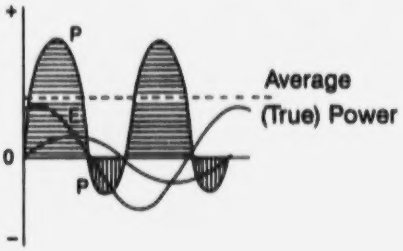
(NOTE: We are unable to make totally pure inductors and therefore all inductors have some resistance within the wire of which they are made.)

B. Power dissipation in an RL circuit occurs in the resistance within the circuit.

C. Since power is dissipated only in the resistance, it may be calculated using the standard power formulas

$$P = EI \qquad P = I^2R \qquad P = \frac{E^2}{R}$$


Power Consumed by the Inductor
+
P
E
I
0
Average Power - Zero
P
–
Power Returned to the Circuit by the Inductor


+
P
Average (True) Power
E
0
P
–

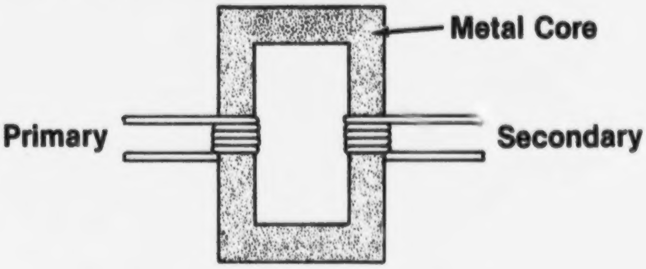
INFORMATION SHEET

VII. Characteristics of a transformer

A. The transformer is one use of the induction process.

B. Different electrical devices require different operating voltages. Transformers change these voltages to meet a specific need.

C. Transformers have three basic parts: a primary conductor, a secondary conductor, and a metal core.



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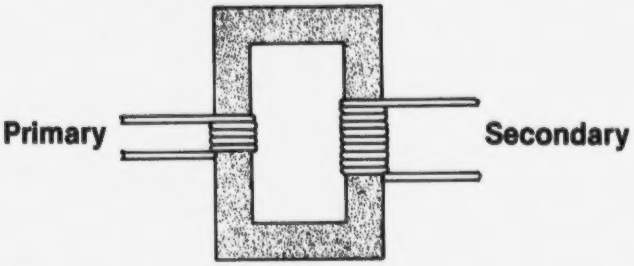
D. When the windings on the primary side are decreased and the windings on the secondary side are increased, this is called a step-up transformer.



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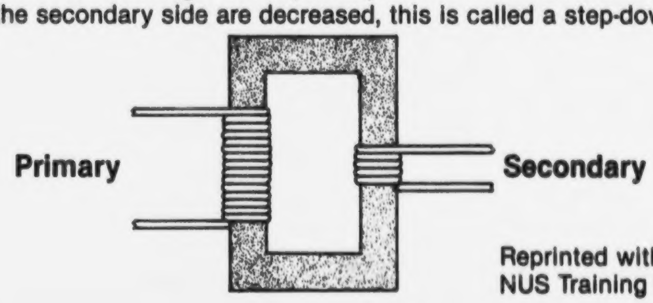
E. When the windings on the primary side are increased and the windings on the secondary side are decreased, this is called a step-down transformer.



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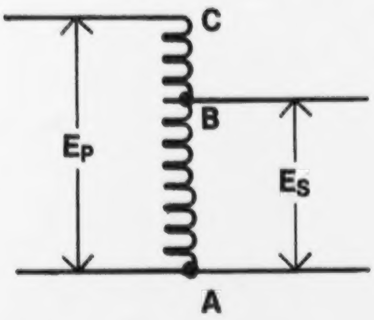
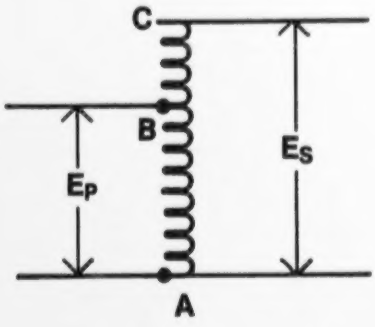
INFORMATION SHEET

F. Autotransformers have a single winding that acts as a primary and secondary.

EXAMPLES:



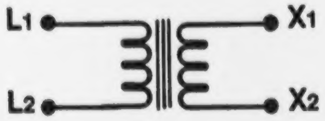
Step-Down Autotransformer



Step-Up Autotransformer

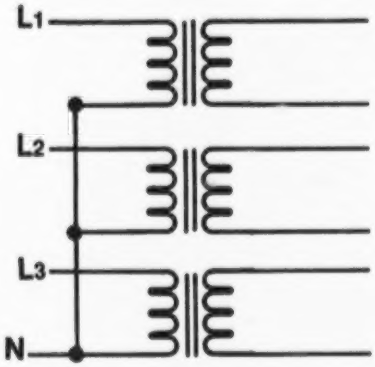
VIII. Classes of transformers

A. Single phase



INFORMATION SHEET

B. Three-phase

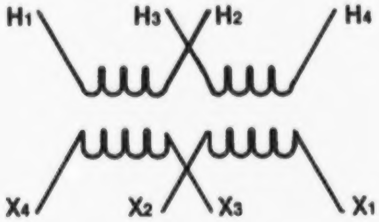


(NOTE: Three single phase transformers can be used to make a three phase transformer if they are of the same values.)

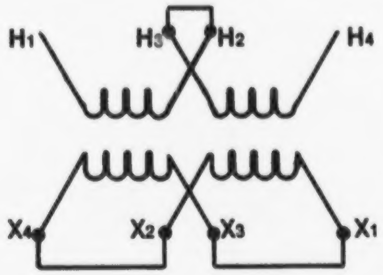
IX. Transformer connections on a three-phase delta system

(NOTE: These are the four most common connections.

A. Dual winding transformer

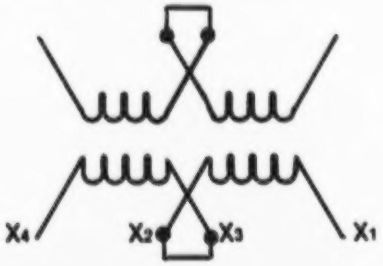

H1
H3
H2
H4
X4
X2
X3
X1

B. Series primary and parallel secondary

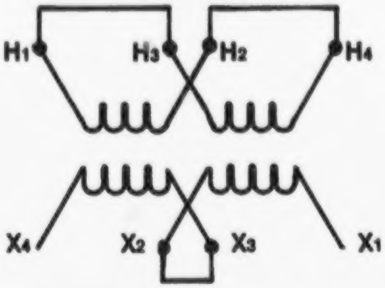

H1
H3
H2
H4
X4
X2
X3
X1

INFORMATION SHEET

C. Series primary and series secondary

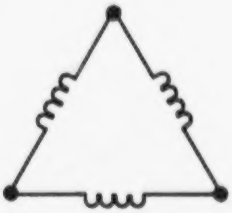


D. Parallel primary and series secondary

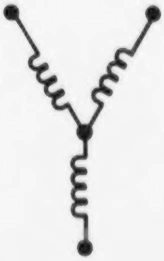

H1
H3
H2
H4
X4
X2
X3
X1

X. Other transformer connections found in electrical trades

A. Delta

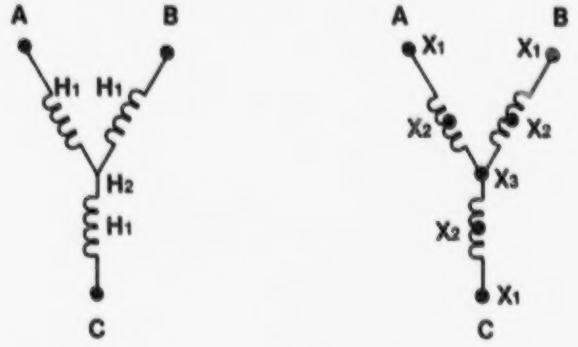


B. Wye

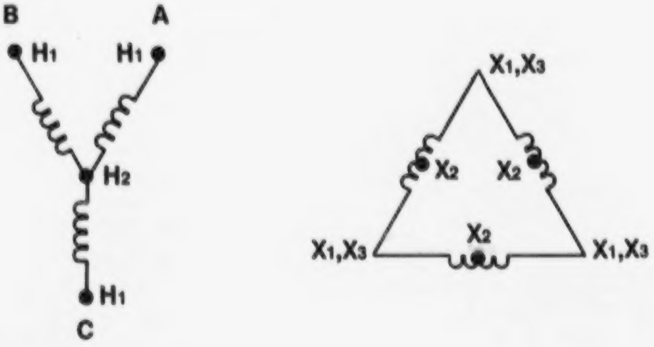


INFORMATION SHEET

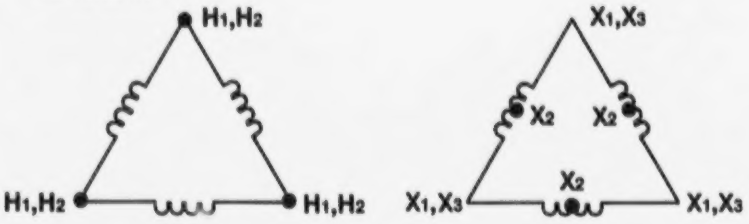
C. Wye-wye


A
B
H1
H1
H2
H1
C
A
B
X1
X1
X2
X2
X3
X2
X1
C

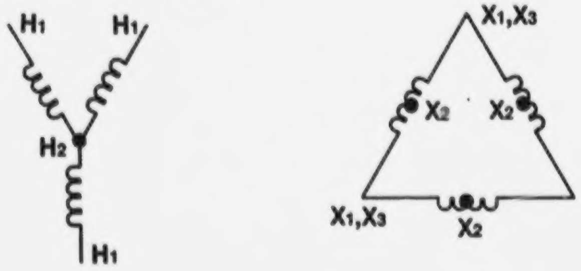
D. Wye-delta


B
A
H1
H1
H2
H1
C
X1,X3
X2
X2
X2
X1,X3
X1,X3

E. Delta-delta


H1,H2
H1,H2
H1,H2
X1,X3
X2
X2
X2
X1,X3
X1,X3

F. Wye-delta four wire system


H1
H1
H2
H1
X1,X3
X2
X2
X1,X3
X2

INFORMATION SHEET

XI. **Power in three-phase circuits**

A. Delta — Voltage across each load member is the full-line voltage; amperage in each member is $\sqrt{3}$ × line amps or 1.732 × amps

B. Wye — Amperage in each member is full-line amperage; voltage across each member is $\sqrt{3}$ × line volts or 1.732 × line volts.

(NOTE: To find the power in delta or wye circuits, use the formula $P = I \times \sqrt{3} \times E$.)

EXAMPLE: A three-phase circuit has 10 amperes measured on each line. The voltage is 480 volts. It is not known whether the circuit is delta or wye. What is the power of the circuit?

Solution: $P = I \times \sqrt{3} \times E$

$= 10 \times 480 \times 1.732$

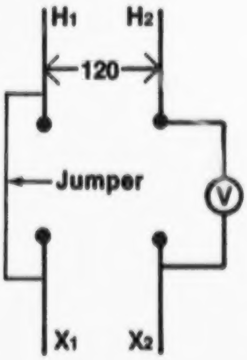
$= 8{,}314$ VA

$= 8.3$ kVA

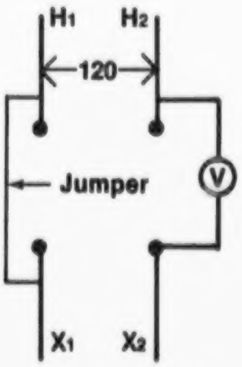
XII. **Testing for polarity**

A. When testing a transformer for polarity, there are two kinds of windings: additives and subtractives.

EXAMPLES:



Voltage reading over 120V
Additive



Voltage reading under 120V
Subtractive

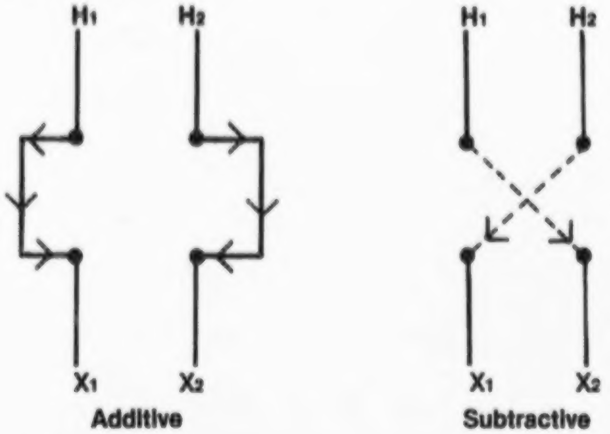
B. When testing a transformer for polarity, connect the primary to the secondary on one side and connect a meter between the primary and secondary on the other side. Apply the primary voltage. If the polarity is additive the meter will read the primary voltage plus the secondary voltage. If the polarity is subtractive the meter will read something less than the applied voltage.

INFORMATION SHEET

C. When finding the taps for an additive transformer, the taps are usually directly under each other.

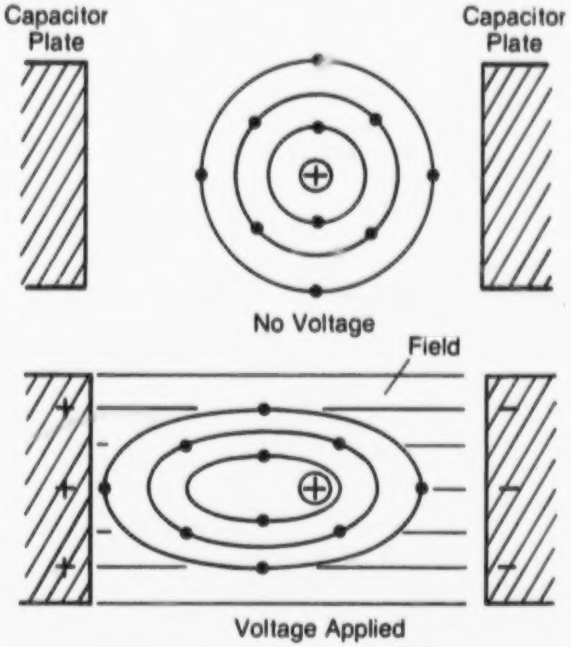
D. When finding the taps for a subtractive transformer, the taps are usually opposite each other.

EXAMPLES:


H1
H2
X1
X2
Additive
H1
H2
X1
X2
Subtractive

XIII. Characteristics of capacitance

A. The property of a circuit or device which enables it to store electrical energy with an electrostatic field is called capacitance.


Capacitor Plate
Capacitor Plate
No Voltage
Field
Voltage Applied

INFORMATION SHEET

B. A device that is made to have a specific value of capacitance is called a capacitor.

   1. The number of electrons that a capacitor can store for a given applied voltage is a measure of its capacitance.

   2. A capacitor has the ability to store electrons and discharge them at a later time.

C. A capacitor is a device constructed of two metal plates separated by a dielectric.

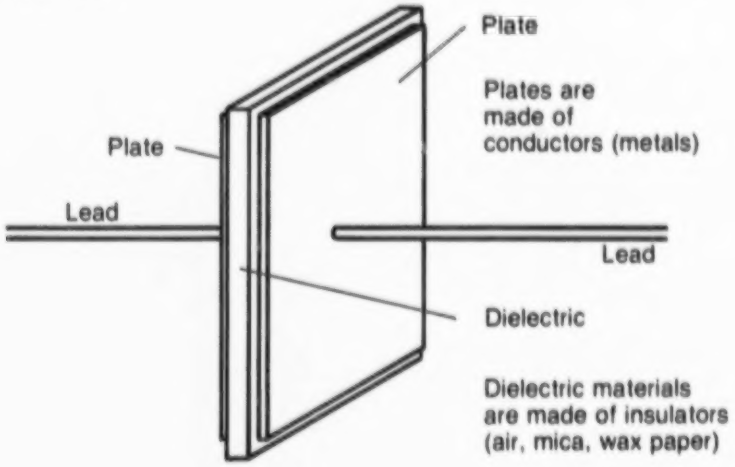
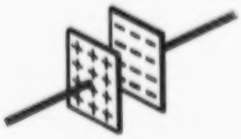
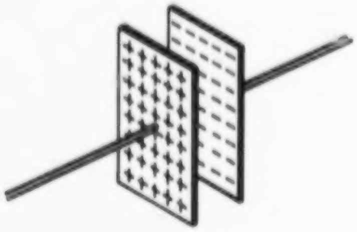


Plate
Plates are made of conductors (metals)
Plate
Lead
Lead
Dielectric
Dielectric materials are made of insulators (air, mica, wax paper)

D. Capacitance of a capacitor is determined by three factors:

   1. The **area** of the metal plates

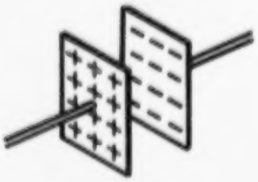




INFORMATION SHEET

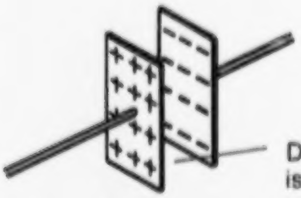
2. The **spacing** between the plates

   (NOTE: The distance between two charges determines their effect. Increasing the distance between the plates decreases capacitance.)

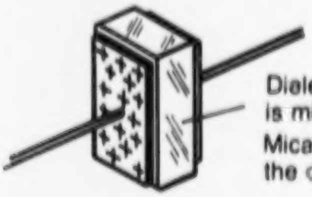


3. The **type** or **nature** of the dielectric

   (NOTE: Changing the dielectric material changes the capacitance.)



Dielectrical material is air.



Dielectrical material is mica.
Mica dielectric increases the capacitance.

E. The unit of capacitance is the farad (F).

F. One farad is the amount of capacitance which will store a charge of one coulomb when one volt of EMF is applied.

   (NOTE: The farad is a very large unit and therefore is commonly expressed in terms of micro-farads or pico-farads.)

G. Capacitance may be expressed in terms of charge and voltage by the formula $C = Q/E$ (C is the capacitance, Q is the quantity of electrical charge in coulombs, and E is the applied voltage.)

INFORMATION SHEET

XIV. Types, ratings, and common defects of capacitors

A. Capacitors are classified according to a number of factors.

1. There are two basic types: fixed value capacitors and variable capacitors.

2. Capacitors are classified by the type of dielectric used such as mica, ceramic, paper, and mylar.

3. Capacitors may be an electrolytic type.

   (NOTE: Polarity must be observed.)

B. Capacitors are rated according to value of capacitance.

C. Defects in capacitors are related to four common failures:

1. Shorts occur when the dielectric is punctured or otherwise fails.

2. A capacitor may open when one or both leads become disconnected from the plates.

3. Excessive leakage may develop when a resistive path forms between the two plates (partial failure of dielectric.)

4. The capacitor may change in value due to a manufacturing defect or improper use (excessive temperature or applied voltage may cause a change in value.)

XV. Characteristics of impedance in RC circuits

A. The total opposition to current flow in a resistive-capacitive AC circuit offered by the resistance and capacitance is called impedance.

B. Impedance is expressed in ohms.

C. The impedance of an RC circuit may be calculated by dividing the applied voltage by the total circuit current.

$$\text{Impedance } Z = \frac{E_a}{I_T}$$

D. The impedance of an RC circuit may also be determined by using Phythagorean's theorem using the resistance and capacitive reactance in the circuit.

$$Z = \sqrt{R^2 + X_C^2}$$

(NOTE: Resistance and inductive reactance may also be found by using the Phythagorean theorem as noted below.)

$$R = \sqrt{Z^2 - X_C^2} \qquad X_C = \sqrt{Z^2 - R^2}$$

INFORMATION SHEET

XVI. Characteristics of impedance in RL circuits

A. The total opposition to current flow offered by both the resistor and inductor in an RL circuit is called impedance.

B. Impedance is expressed in ohms.

C. The applied voltage and the circuit current may be used to determine the impedance according to Ohm's law.

$$\text{Impedance } Z = \frac{E_a}{I_T}$$

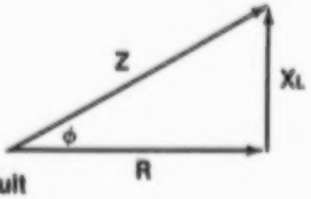
D. The impedance of a series RL circuit also may be determined by vector summation of resistance and the inductive reactance.

$$Z = \sqrt{R^2 + X_L^2}$$

(NOTE: Resistance and inductive reactance may also be found using Pythagorean theorem and noted below with the impedance triangle of a series RL circuits.)

$$R = \sqrt{Z^2 - X_L^2}$$

$$X_L = \sqrt{Z^2 - R^2}$$



XVII. Characteristics of power in an AC circuit

A. In an AC circuit, voltage and current are seldom in phase.

(NOTE: The exception would be with incandescent lights and heating circuits.)

B. The power or product of voltage and current must be multiplied by a power factor to determine the true power.

EXAMPLE: Power (watts) = volts × amperes

$P = E \times I$

$$\text{(Power factor) PF} = \frac{\text{true power}}{\text{apparent power}}$$

INFORMATION SHEET

C. By using a meter we can determine the true power in a circuit.

EXAMPLE: A voltmeter reads 120 volts and the amp meter reads 10 amps. A wattmenter gives a reading of 1000w of true power.

$P = E \times I$

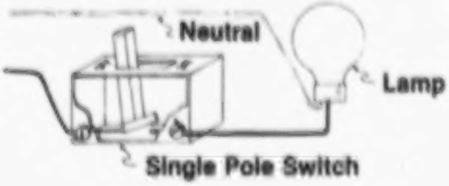
$P = 120 \times 10 = 1200$ watts

$PF = \frac{1000}{1200}$ true power

$PF = 83\%$ or $.83$

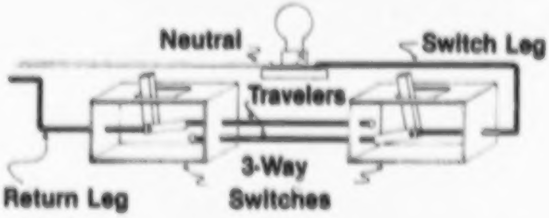
XVIII. Basic switching circuits used in electricity

A. Single pole switch


Neutral
Lamp
Single Pole Switch

(NOTE: A single pole switch only breaks the circuit in one position.)

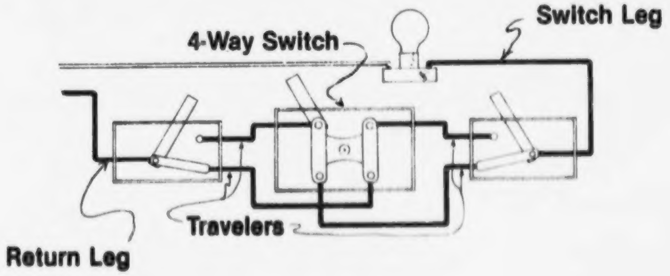
B. Three-way switch


Neutral
Switch Leg
Travelers
3-Way Switches
Return Leg

(NOTE: A three-way switch breaks the circuit in two positions.)

INFORMATION SHEET

C. Four-way switch


4-Way Switch
Switch Leg
Travelers
Return Leg

(NOTE: When wired with two three-way switches, as many four-way switches can be installed as needed, making the operation from many positions.)

AC CIRCUITS
UNIT X

ASSIGNMENT SHEET #1 — SOLVE POWER FACTOR PROBLEMS

NAME ____ SCORE ________________

Directions: Find the power factor for the following problems. Show calculations in the space provided below each answer.

1. A voltmeter reads 200 volts and an amp meter reads 10 amps. The wattmeter has a reading of 1400 watts. What is the power factor. ____________

2. What is the power factor on a device having 150v and 14 amp and a watt reading 1600 watts. ____________

3. With a 120v and 12 amp rating on a circuit and the true power is 1200 watts. What is the power factor. ____________

4. When the apparent power is 1200 watts, but the true power is 1000 watts. What is the power factor. ____________

5. When the true power on a circuit is 1400 watts and the apparent power is 2000 watts. What is the power factor. ____________

AC CIRCUITS
UNIT X

ASSIGNMENT SHEET #2 — SOLVE RC AND RL CIRCUIT PROBLEMS

NAME ____ SCORE ____________

Directions: Solve RC and RL circuit problems. Show calculations in the space provided below each answer.

1. In a parallel RL circuit, the applied voltage is 100V the measured value of I_L = 0.2 amps and of I_R = 0.5A. The numerical value of I_T = ____________ A.

2. The angle Θ by which total current I_T (in question 1) ____________ (leads/lags); the applied voltage V is ____________ degrees.

3. The impedance of the circuit in question 1 is ____________ Ω.

4. In a parallel RC circuit, the applied voltage V = 300, and the measured values of I_C = 0.1A and I_R = 0.2A. The numerical value of I_T = ____________ A.

ASSIGNMENT SHEET #2

5. The angle Θ by which the total current I_T (in question 4) ____________ (leads/lags); the applied voltage V is ____________ degrees.

6. The impedance of the circuit in question 4 is ____________ Ω.

AC CIRCUITS
UNIT X

ASSIGNMENT SHEET #3 — DRAW A DIAGRAM OF A SINGLE POLE SWITCH ON A LIGHT

NAME ________________________________ SCORE ______________

Directions: Draw a diagram of a single pole switch on a light in the space provided.

AC CIRCUITS
UNIT X

ASSIGNMENT SHEET #4 — DRAW A DIAGRAM OF TWO THREE-WAY SWITCHES ON A LIGHT

NAME ______________________________ SCORE ______________

Directions: Draw a diagram of two three-way switches on a light in the space provided.

AC CIRCUITS
UNIT X

ASSIGNMENT SHEET #5 — DRAW A DIAGRAM OF TWO THREE-WAY SWITCHES AND A FOUR-WAY SWITCH ON A LIGHT

NAME ______________________________ SCORE ______________

Directions: Draw a diagram of two three-way switches and a four-way switch on a light in the space provided.

AC CIRCUITS
UNIT X

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. .70 70%
2. .76 76%
3. .83 83%
4. .83 83%
5. .70 70%

Assignment Sheet #2

1. 0.539
2. Lags; 21.8°
3. 186
4. 0.224
5. Leads; 26.60
6. 134

Assignment Sheet #3 — Evaluated to the satisfaction of the instructor

Assignment Sheet #4 — Evaluated to the satisfaction of the instructor

Assignment Sheet #5 — Evaluated to the satisfaction of the instructor

AC CIRCUITS
UNIT X

JOB SHEET #1 — WIRE A SINGLE POLE SWITCH CONTROLLING A SINGLE LIGHTING OUTLET WITH THE SUPPLY LINE ENTERING THE SWITCH BOX

A. Equipment and materials needed

1. 12-2-G or 14-2-G NM cable
2. Device box
3. Octagon box

   (NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors you will install.)

4. Staples
5. Single pole switch
6. Light socket
7. Bar hanger

   (NOTE: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)

8. Stud wall or work board
9. 120v supply

   (NOTE: The overcurrent supply should not exceed your conductors NEC ampacity rating.)

10. 3/8" cable clamp

    (NOTE: This fits a one-half inch knockout.)

11. 120v incandescent bulb
12. Wire connectors

    (NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)

13. Two 16 penny nails

JOB SHEET #1

14. 2 plasterboard nails
15. Electrician's hammer
16. Long nose pliers
17. Pocket knife
18. Wire strippers
19. Tool pouch
20. Drill motor or brace
21. ½" or larger wood bit

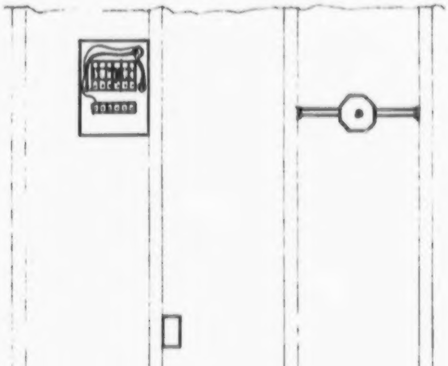
    (NOTE: Hole should be large enough to safely accommodate cable.)
22. Extension cord
23. Safety glasses
24. Portable GFI

B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes. (Figure 1)

    (NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)

    FIGURE 1



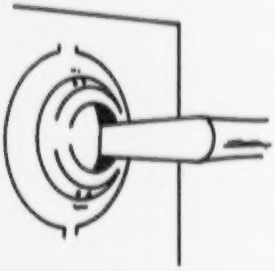
JOB SHEET #1

3. Remove a half inch knockout from the panel.

   a. Locate ½" KO (knockout) to be removed.

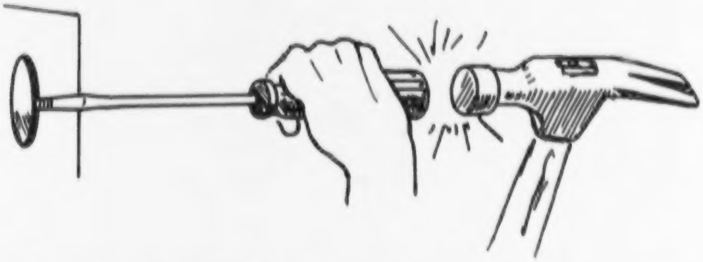
   b. Place screwdriver on KO at point opposite unstamped piece. (Figure 2)

FIGURE 2



   c. Hit screwdriver handle crisply with hammer. (Figure 3)

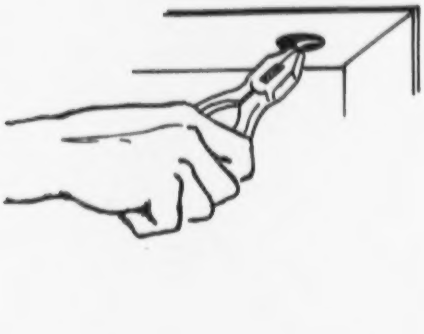
FIGURE 3



   d. Grasp raised KO with lineman's pliers.

   e. Bend KO back and forth until removed. (Figure 4)

FIGURE 4

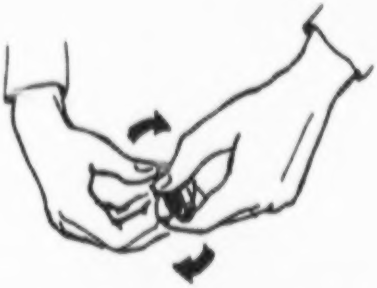


JOB SHEET #1

4. Install cable connector.

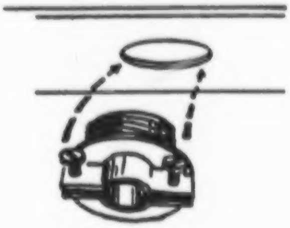
   a. Hold connector and unscrew locknut. (Figure 5)

FIGURE 5



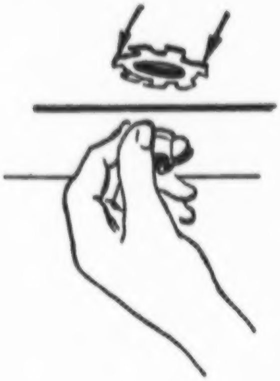
   b. Place threads through KO opening. (Figure 6)

FIGURE 6



   c. Install locknut. (Figure 7)

FIGURE 7

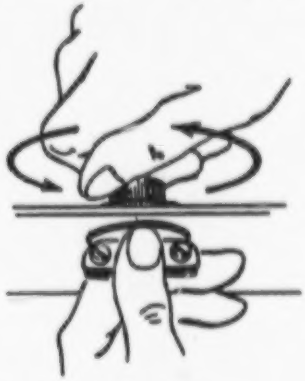


JOB SHEET #1

d. Tighten locknut. (Figure 8)

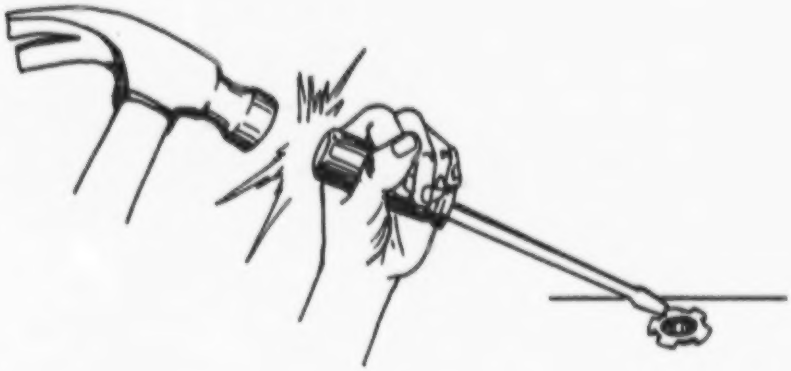
(NOTE: Be sure serrated teeth are in contact with box.)

FIGURE 8



e. Tighten locknut securely. (Figure 9)

FIGURE 9



5. Plug cord into portable GFI.

6. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below box depending on which route is the closest.)

(CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.)

JOB SHEET #1

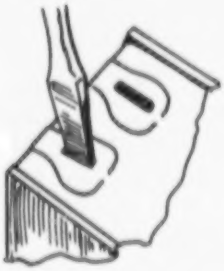
7. Run cable.

   a. Remove KO's from boxes.

      1) Place screwdriver in slot. (Figure 10)

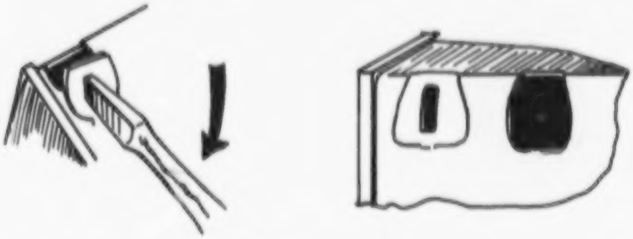
         (NOTE: This is for metal boxes; most plastic boxes have KOs that are broken out by placing a screwdriver in the center and hitting with your hand or hammer.)

         FIGURE 10



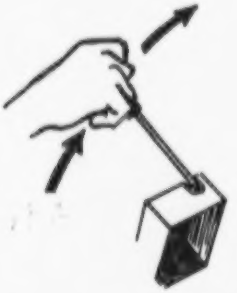
      2) Pry KO out. (Figure 11)

         FIGURE 11



      3) Wiggle screwdriver until KO pops loose. (Figure 12)

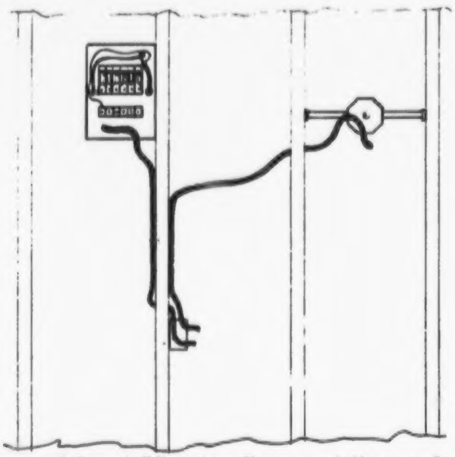
         FIGURE 12



JOB SHEET #1

b. Run cable between boxes. (Figure 13)

FIGURE 13



(NOTE: Leave at least 8" extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus 1/2 of the width.)

8. Staple cable within 12" of all metal boxes, 8" of all nonmetallic boxes.

   (NOTE: Cables should be run flat when possible.)

9. Secure all cable clamps and connectors.

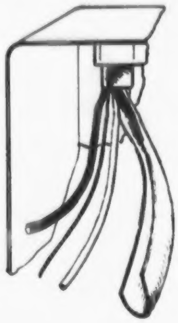
   (CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

10. Strip cable insulation to within 1/4" of its point of entry. (NEC Art: 300-14). (Figure 14)

    CAUTION: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.)

    (NOTE: Cables could be stripped before they are installed in the boxes.)

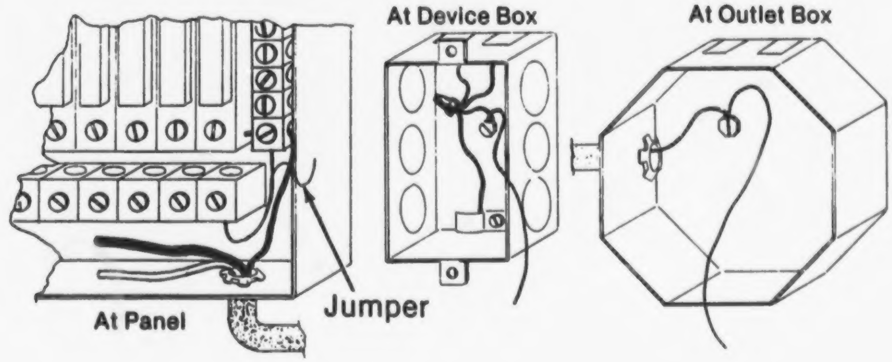
FIGURE 14



JOB SHEET #1

11. Connect all grounding conductors (green or bare). (Figure 15)

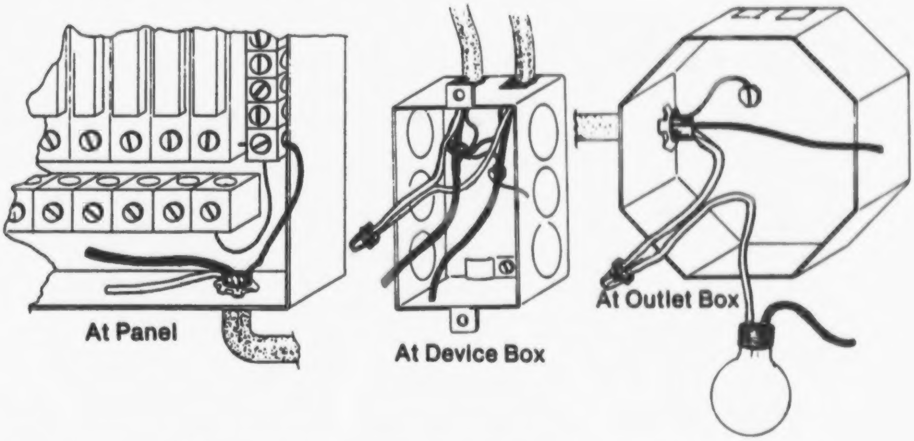
FIGURE 15


At Device Box
At Outlet Box
At Panel
Jumper

(NOTE: Always leave enough conductor to make removal and connection easy. Notice extra bend at panel.)

12. Connect all neutral conductors (white or natural gray). (Figure 16)

FIGURE 16

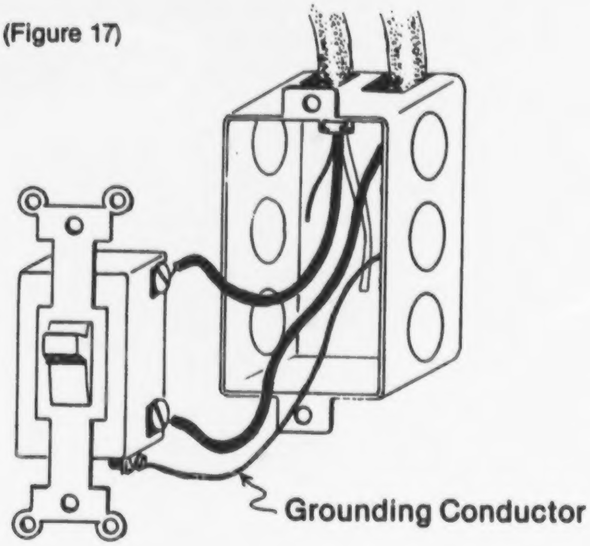

At Panel
At Device Box
At Outlet Box

13. Connect switch leg to remaining lampholder, conductor, or terminal.

JOB SHEET #1

14. Connect switch. (Figure 17)

FIGURE 17



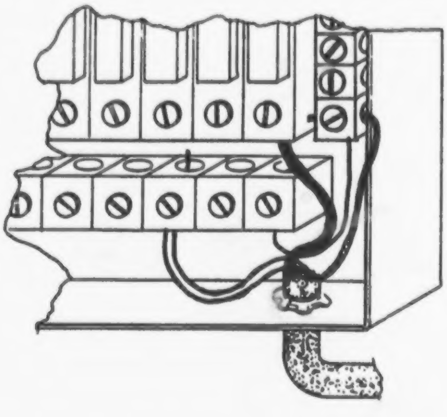
(NOTE: Be sure that the loop in the conductors is turned in the direction that the terminal tightens.)

15. Install the switch in box.

(NOTE: Be sure and push all conductors into the box; don't rely on the installation of the switch to situate them.)

16. Connect ungrounded conductor to appropriate overcurrent device (Figure 18)

FIGURE 18



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.)

JOB SHEET #1

17. Put single pole in off position.

18. Turn breaker on.

    (CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)

19. Turn on the switch.

20. Have your instructor evaluate this project.

21. Turn off breaker.

22. Clean work area; put away all equipment and materials.

AC CIRCUITS
UNIT X

JOB SHEET #2 — WIRE A SINGLE POLE SWITCH CONTROLLING A SINGLE LIGHTING OUTLET WITH THE SUPPLY LINE ENTERING THE LIGHTING OUTLET BOX

A. Equipment and materials needed

1. 12-2-G or 14-2-G NM cable
2. Device box
3. Octagon box

   (NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors you will install.)

4. Staples
5. Single pole switch
6. Light socket
7. Bar hanger

   (NOTE: If a bracket octagon box is used, or if this job is installed on a work board, a bar hanger will not be needed.)

8. Stud wall or work board
9. 120v supply

   (NOTE: The overcurrent supply should not exceed your conductors NEC ampacity rating.)

10. 3/8" cable clamp
11. 120v incandescent bulb
12. Wire connectors

    (NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)

13. Two 16 penny nails
14. 2 plasterboard nails

JOB SHEET #2

15. Electrician's hammer
16. Plain tip screwdriver
17. Lineman's pliers
18. Long nose pliers
19. Pocket knife
20. Wire strippers
21. Tool pouch
22. Drill motor or brace
23. ½" or larger wood bit

    (NOTE: Hole should be large enough to safely accommodate cable.)
24. Extension cord
25. Safety glasses
26. Portable GFI

B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes.

   (NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)
3. Remove a half inch knockout from the panel.
4. Install cable connector.
5. Plug cord into portable GFI.
6. Bore holes for cable.

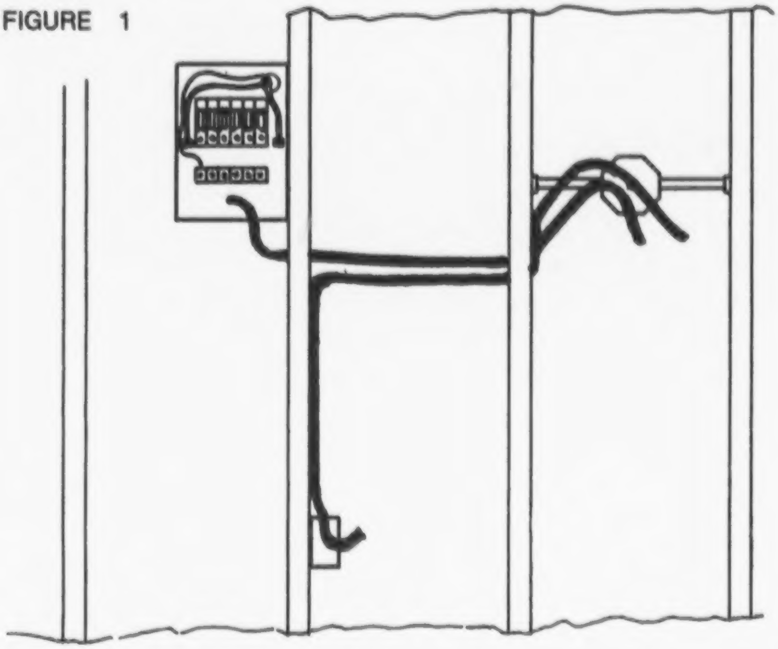
   (NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below box depending on which route is the closest.)

   (CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.)

JOB SHEET #2

7. Run cable. (Figure 1)

FIGURE 1



(NOTE: Leave at least 8" extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus half the width. The cable from the switch should enter the outlet box through the hole closest to the switch for later identification.)

8. Staple cable within 12" of all metal boxes, 8" of all nonmetallic boxes.

9. Secure all cable clamps and connectors.

   (CAUTION: Tighten them until the cable will not slip in the box, overtightening can cause an electrical short.)

10. Strip cable insulation.

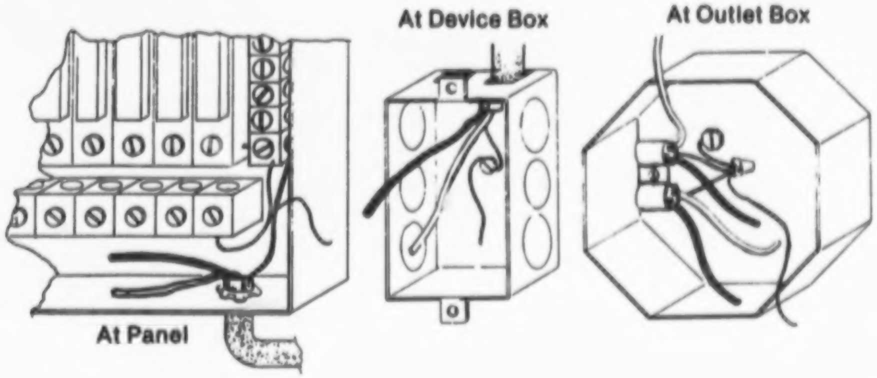
    (NOTE: Trim the cable covering to within 1/4" of its point of entry.)

    (CAUTION: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.)

JOB SHEET #2

11. Connect all grounding conductors (green or bare). (Figure 2)

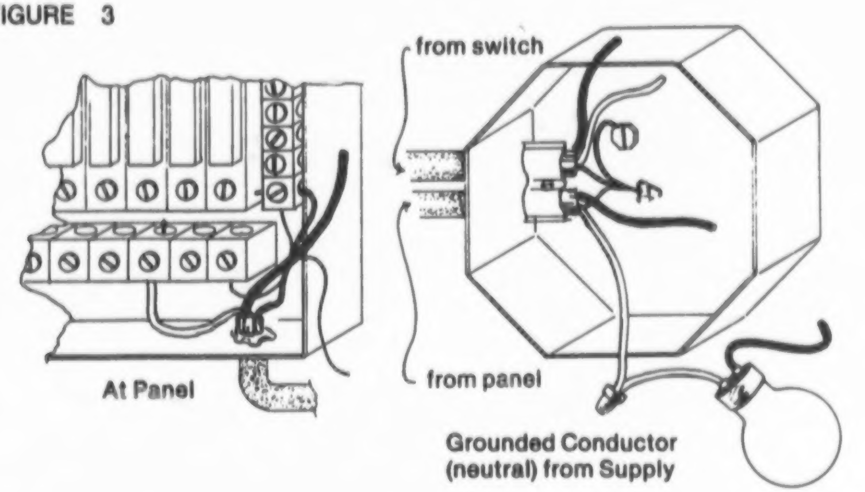
FIGURE 2


At Device Box
At Outlet Box
At Panel

(NOTE: Always leave enough conductor to make removal and reconnection easy. Notice extra bend at panel.)

12. Connect all neutral conductors (white or natural gray). (Figure 3)

FIGURE 3

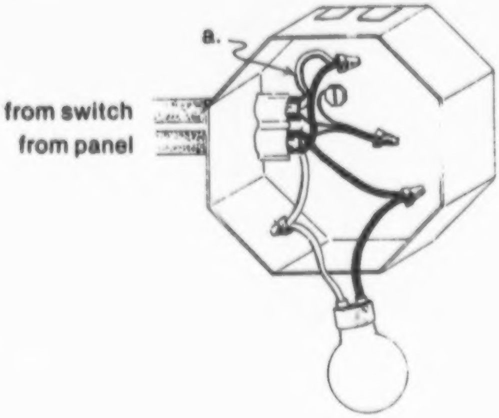

from switch
from panel
At Panel
Grounded Conductor
(neutral) from Supply

(NOTE: The grounded conductor in this circuit goes from the grounded terminal of the panel to the light and stops.)

JOB SHEET #2

13. Make up outlet box. (Figure 4)

FIGURE 4



(NOTE: In switching situations you are allowed to use the white or gray conductor as the hot feed to the switch.)

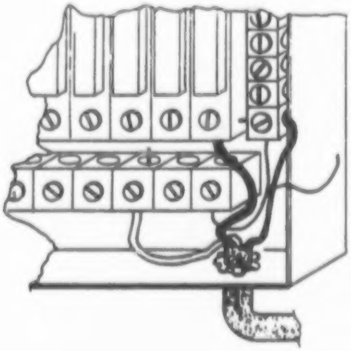
14. Install conductors on switch.

(NOTE: It makes no difference which terminals the white and black conductors go on. The grounding however must go on the green, hex headed screw.)

15. Install switch in box.

16. Connect ungrounded conductor to appropriate overcurrent protection. (Figure 5)

FIGURE 5



(CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

JOB SHEET #2

17. Put switch in off position.

18. Turn breaker on.

    (CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)

19. Turn on the switch.

20. Have your instructor evaluate this project.

21. Turn off breaker.

22. Clean work area; put away all equipment and materials.

AC CIRCUITS
UNIT X

JOB SHEET #3 — WIRE A THREE-WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING A SINGLE LIGHTING OUTLET

A. Equipment and materials needed

1. 12-2-G or 14-2-G and 12-3-G or 14-3G NM cable
2. Two device boxes
3. Octagon box

   (NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors you will install.)

4. Staples
5. Two 3-way switches
6. Light socket
7. Bar hanger

   (NOTE: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)

8. Stud wall or work board
9. 120v supply

   (NOTE: The overcurrent supply should not exceed your conductors NEC ampacity rating.)

10. 3/8" cable clamp
11. 120v incandescent bulb
12. Wire connectors

    (NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)

13. Two 16 penny nails
14. 2 plasterboard nails
15. Electrician's hammer

JOB SHEET #3

16. Plain tip screwdriver
17. Lineman's pliers
18. Needle nose pliers
19. Pocket knife
20. Wire strippers
21. Tool pouch
22. Drill motor or brace
23. ½" or larger wood bit

    (NOTE: Holes should be large enough to safely accommodate the cables.)

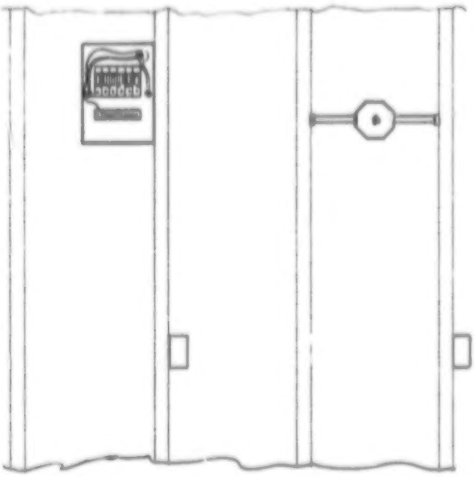
24. Extension cord
25. Safety glasses
26. Portable GFI

B. Procedure

1. Gather equipment and materials.
2. Mount boxes. (Figure 1)

   (NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)

FIGURE 1



JOB SHEET #3

3. Remove a half inch knockout from the panel.

4. Install cable connector.

5. Plug cord into GFI.

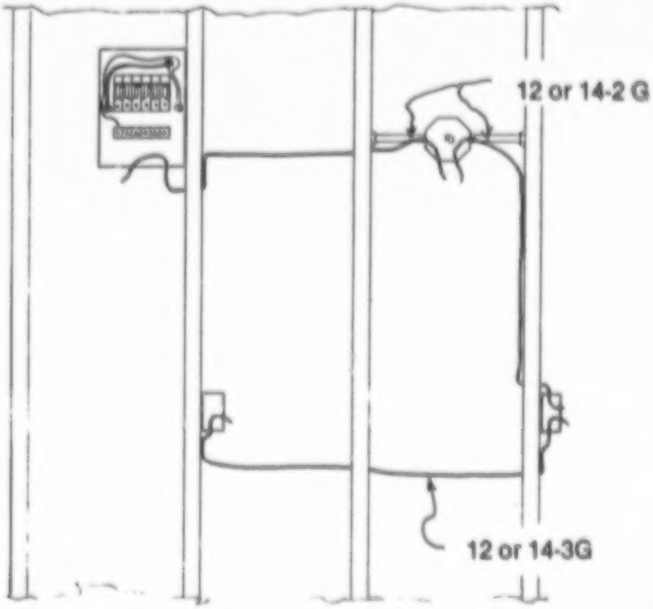
6. Bore holes for cable.

   (NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below box depending on which route is the closest.)

   (CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.)

7. Run cable. (Figure 2)

   FIGURE 2



   (NOTE: Leave at least 8" extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus half the width.)

8. Staple cable within 12" of all metal boxes, 8" of all nonmetallic boxes.

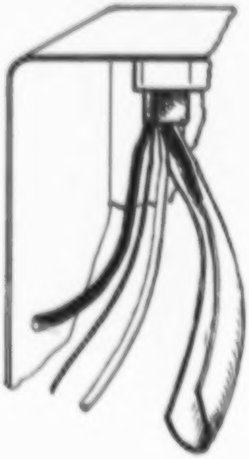
9. Secure all cable clamps and connectors.

   (CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

JOB SHEET #3

10. Strip cable insulation. (Figure 3)

FIGURE 3

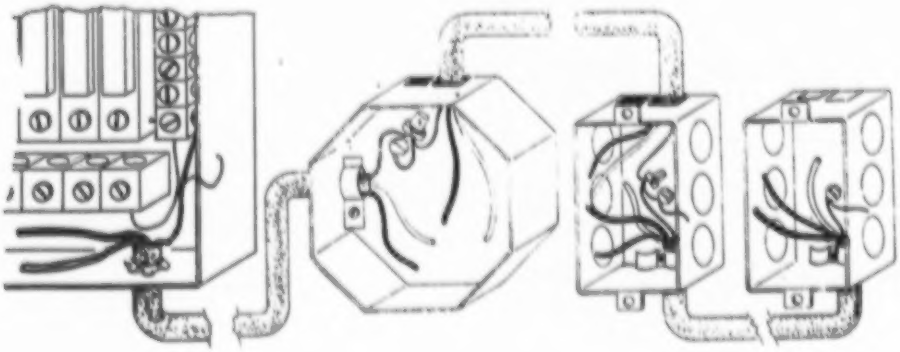


(NOTE: Trim the cable covering to within ¼" of its point of entry.)

(CAUTION: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.)

11. Connect all grounding conductors. (Figure 4)

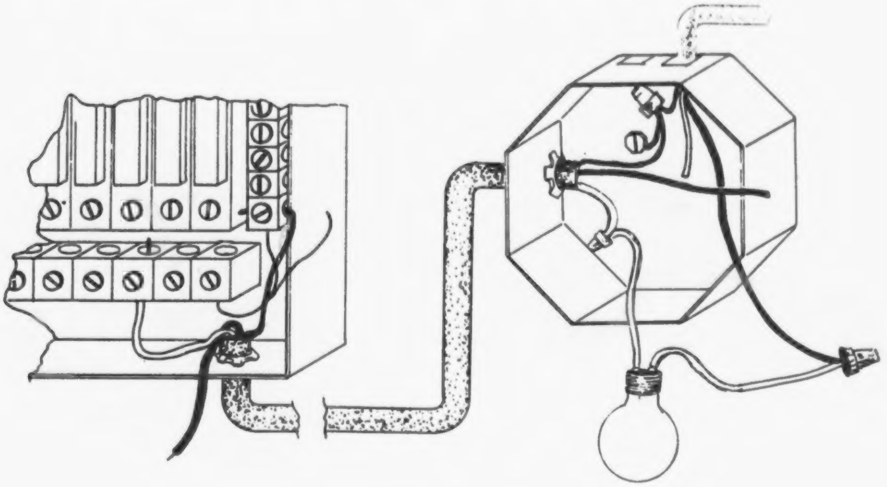
FIGURE 4



JOB SHEET #3

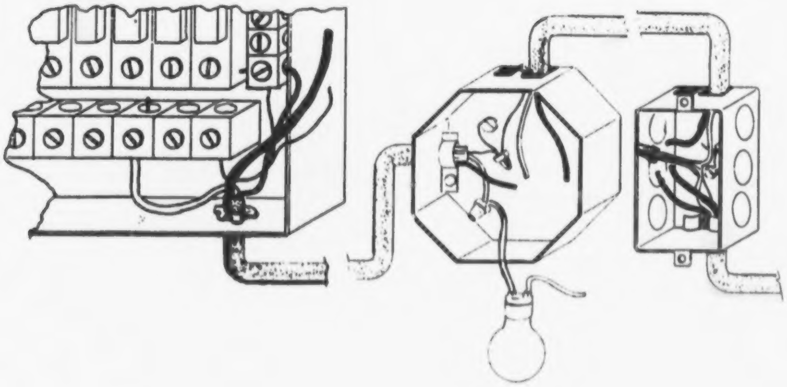
12. Connect neutral conductors. (Figure 5)

FIGURE 5



13. Connect switch legs. (Figure 6)

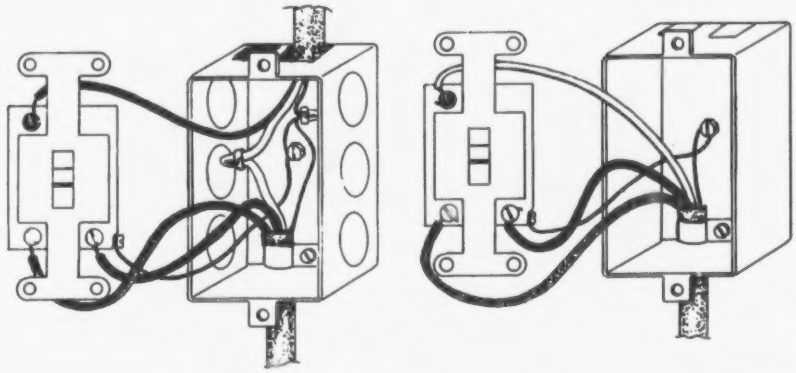
FIGURE 6



JOB SHEET #3

14. Install switches. (Figure 7)

FIGURE 7

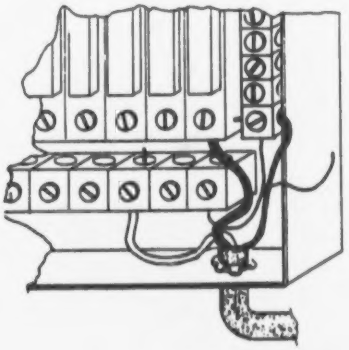


(NOTE: In all three way circuits the switch goes on one common screw and the return leg goes on the other with travelers connecting to the remaining screws on each device. The grounding screw attaches to the green hex headed screw on the strap.)

15. Connect return leg to socket.

16. Connect ungrounded conductor to appropriate overcurrent device. (Figure 8)

FIGURE 8



(CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

JOB SHEET #3

17. Turn breaker on.

    (CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)

18. Change the position of the switches in alternating movements.

    (NOTE: Be sure you can turn the light on or off from either switch as well as on at one and off at the other.)

19. Have instructor evaluate this project.

20. Turn off breaker.

21. Clean work area; put away all equipment and materials.

AC CIRCUITS
UNIT X

JOB SHEET #4 — WIRE A FOUR-WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING THE LIGHTING OUTLET BOX

A. Equipment and materials needed

1. 12-2-G or 14-2-G and
   12-3-G or 14-3-G NM cable
2. Three device boxes
3. Octagon box

   (NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors you will install.)
4. Staples
5. Two 3-way switches
6. One 4-way switch
7. Light socket
8. Bar hanger

   (NOTE: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)
9. Stud wall or work board
10. 120v supply

    (NOTE: The overcurrent supply should not exceed your conductors NEC ampacity rating.)
11. 3/8" cable clamp
12. 120v incandescent bulb
13. Wire connectors

    (NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
14. Two 16 penny nails
15. Two plasterboard nails

16. Electrician's hammer
17. Plain tip screwdriver
18. Lineman's pliers
19. Needle nose pliers
20. Pocket knife
21. Wire strippers
22. Tool pouch
23. Drill motor or brace
24. ½" or larger wood bit

    (NOTE: Holes should be large enough to safely accommodate the cables.)

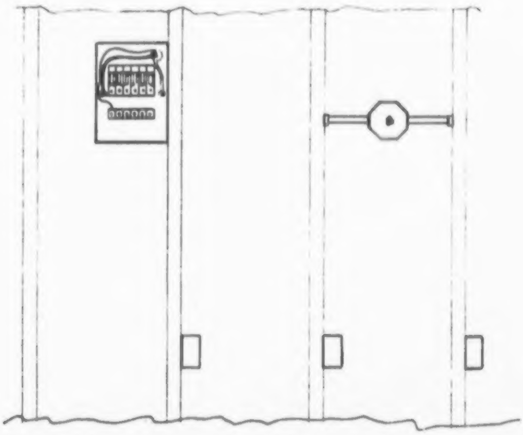
25. Extension cord
26. Safety glasses
27. Portable GFI

B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes. (Figure 1)

   (NOTE: See instructor for mounting location.)

FIGURE 1



JOB SHEET #4

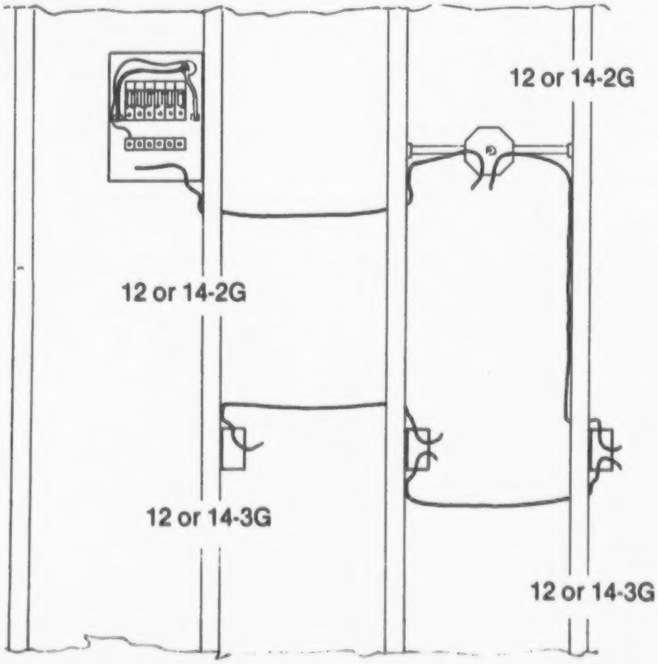
3. Remove a half inch knockout from the panel.
4. Install cable connector.
5. Plug cord into GFI.
6. Bore holes for cable.

   (NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below box depending on which route is the closest.)

   (CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.)

7. Run cable. (Figure 2)

FIGURE 2



(NOTE: Leave at least 8" extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus half the width.)

8. **Staple cable within 12" of all metal boxes, 8" of all nonmetallic single gang boxes.**

   (NOTE: Refer to NEC 336-15.)

9. **Secure all cable clamps and connectors.**

   (CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

JOB SHEET #4

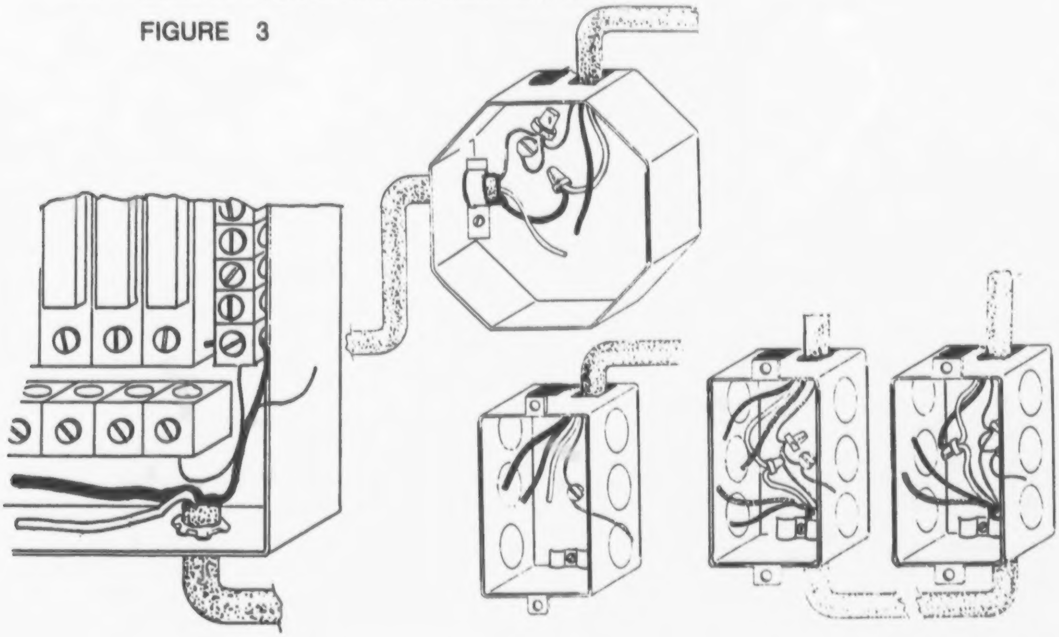
10. Strip cable insulation.

(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

(CAUTION: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.)

11. Connect all grounding conductors. (Figure 3)

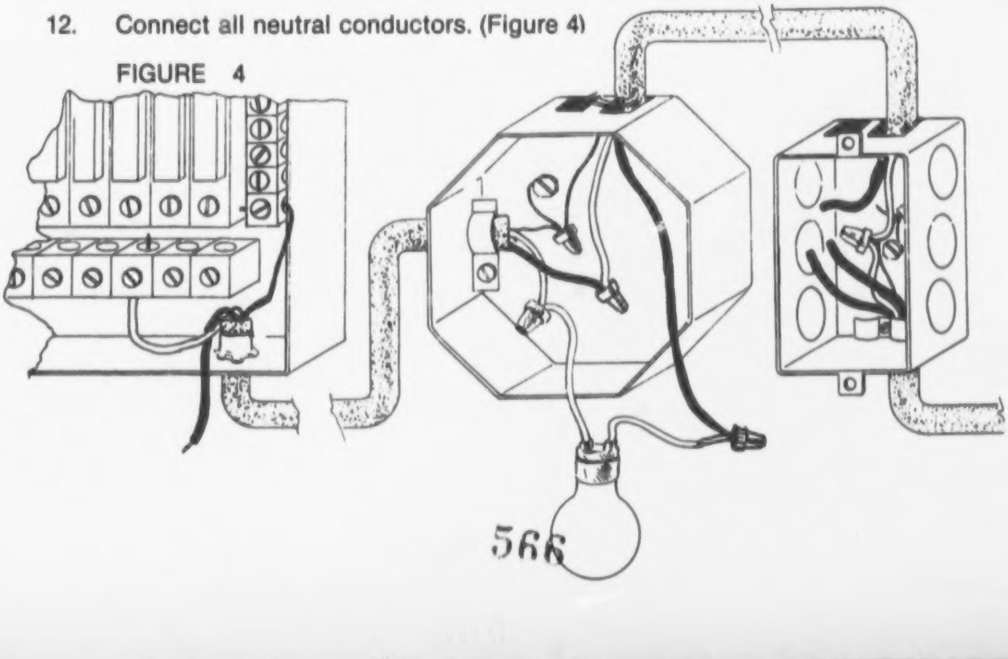
FIGURE 3



(NOTE: Always leave enough conductor to make removal and reconnection easy. Notice extra bend at panel.)

12. Connect all neutral conductors. (Figure 4)

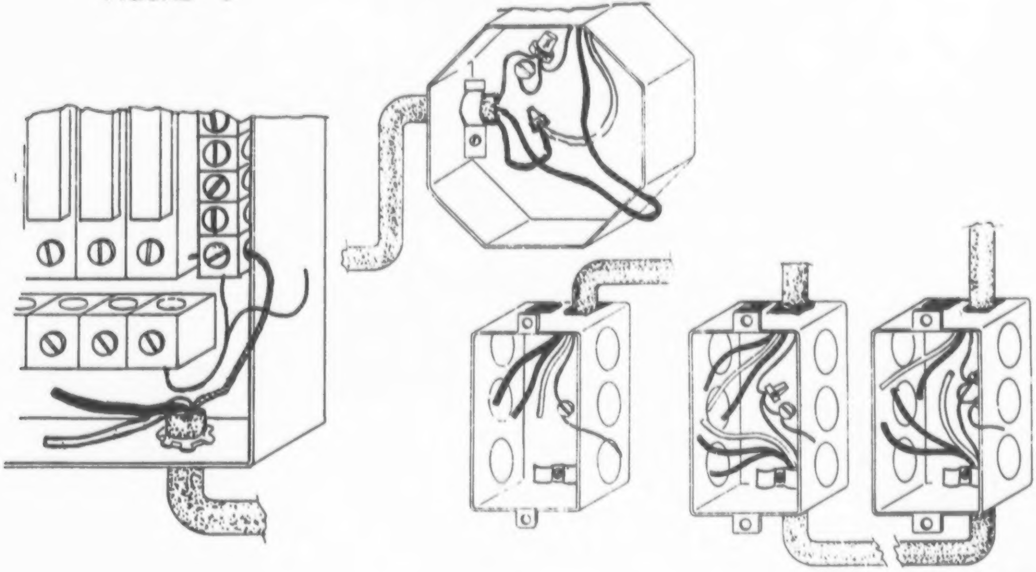
FIGURE 4



JOB SHEET #4

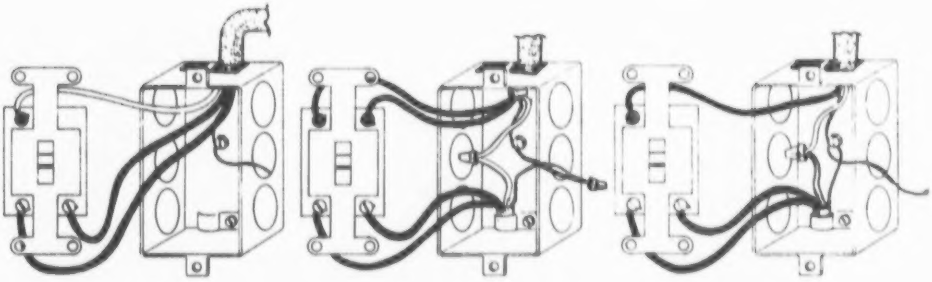
13. Connect switch legs through the system. (Figure 5)

FIGURE 5



14. Install switches. (Figure 6)

FIGURE 6

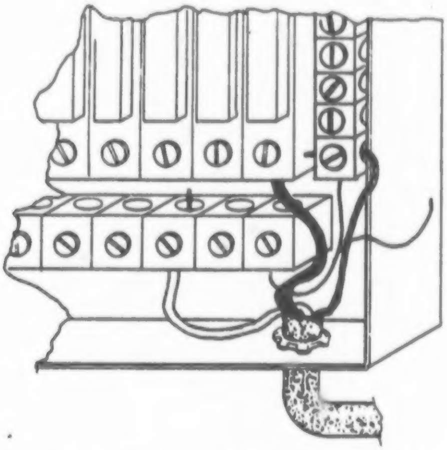


JOB SHEET #4

15. Connect switch leg to socket.

16. Connect ungrounded conductor to appropriate overcurrent device. (Figure 7)

FIGURE 7



(CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

17. Turn breaker on.

(CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)

18. Change the position of the switches in alternating movements.

(NOTE: Be sure you can turn the light on or off from either switch as well as on at one and off at the other.)

19. Have instructor evaluate this project.

20. Turn off breaker.

21. Clean work area; put away all equipment and materials.

AC CIRCUITS
UNIT X

PRACTICAL TEST
JOB SHEET #1 — WIRE A SINGLE POLE SWITCH CONTROLLING A SINGLE LIGHTING OUTLET WITH THE SUPPLY LINE ENTERING THE SWITCH BOX

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted boxes correctly on studs.	______	______
3. Removed the KO safely and correctly.	______	______
4. Installed the wire connector in KO.	______	______
5. Tightened the locknut with correct tools.	______	______
6. Ran and stapled romex properly.	______	______
7. Left the right length of conductors out of box.	______	______
8. Terminated all ground wires in boxes.	______	______
9. Connected conductors to switch and light properly.	______	______
10. Drilled all holes to NEC code.	______	______
11. Tested circuit before breaker was turned on.	______	______
12. Checked project to see if it works.	______	______
13. Checked in/put away tools and materials.	______	______
14. Cleaned the work area.	______	______
15. Used proper tools correctly.	______	______
16. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
17. Practiced safety rules throughout procedure.	______	______
18. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Boxes mounted properly	4	3	2	1
Devices wired properly	4	3	2	1
Circuit switch worked correctly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

AC CIRCUITS
UNIT X

PRACTICAL TEST
JOB SHEET #2 — WIRE A SINGLE POLE SWITCH CONTROLLING A SINGLE LIGHTING OUTLET WITH THE SUPPLY LINE ENTERING THE LIGHTING BOX OUTLET

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted boxes on studs correctly.	______	______
3. Bored holes to NEC.	______	______
4. Ran wiring connector to bores.	______	______
5. Installed switch and light.	______	______
6. Grounded all devices and boxes.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Switch and light installed correctly	4	3	2	1
Circuit worked correctly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

AC CIRCUITS
UNIT X

PRACTICAL TEST
JOB SHEET #3 — WIRE A THREE-WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING A SINGLE LIGHTING OUTLET

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted all boxes on studs properly.	______	______
3. Bored holes to NEC.	______	______
4. Ran wiring correctly to boxes.	______	______
5. Installed all devices correctly.	______	______
6. All boxes grounded.	______	______
7. All make up tight.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Mounted boxes correctly	4	3	2	1
Switch and light installed correctly	4	3	2	1
Circuit worked correctly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

AC CIRCUITS
UNIT X

PRACTICAL TEST
JOB SHEET #4 — WIRE A FOUR-WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING THE LIGHTING OUTLET BOX

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted all boxes on studs properly.	______	______
3. Bored holes to NEC.	______	______
4. Ran wiring correctly to boxes.	______	______
5. Installed all devices correctly.	______	______
6. All boxes grounded.	______	______
7. All make up tight.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Mounted boxes correctly	4	3	2	1
Switches and light installed correctly	4	3	2	1
Circuit worked correctly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

AC CIRCUITS
UNIT X

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

______a. The shape of a wave as a function of time, distance, and amplitude

______b. One power source

______c. Transformer with a single winding

______d. A resistance to current flow

______e. Termination points where conductors are joined together

______f. The power that a device is actually using

______g. Amount of inductance into a conductor when the current changes at the rate one ampere per second

______h. Where voltage enters a transformer

______i. Conductors coiled around a metal core in a transformer or motor

______j. Insulating materials capable of accumulating an electrical charge

______k. Where voltage leaves a transformer

______l. Term used to describe the power which "appears" to be consumed in an RC circuit when the power formula P = IE is applied to the circuit

1. Apparent power
2. Autotransformer
3. Connections
4. Dielectric materials
5. Henry
6. Opposition
7. Primary
8. Secondary
9. Single phase
10. True power
11. Waveform
12. Windings

TEST

2. Select true statements concerning principles of AC theory by placing an "X" in the blanks preceding the true statements.

_____a. AC current flows in two directions; it flows in one direction, stops, and then flows in the opposite direction.

_____b. There are two basic types of waveforms: square wave and sawtooth wave.

_____c. Sine waves are measured peak-to-peak in AC voltage or amperes.

_____d. Peak-to-peak current and voltages occur three times in a cycle: one in the positive direction, one in neutral, and one in the negative direction.

_____e. The rms (root-mean-square) or effective value of the sine wave is .007 times peak value.

_____f. Electromotive force (emf) causes current to flow through a device; this is referred to in sine waves as V.

3. Complete the following statements related to the principles of induction by inserting the word(s) that best completes each statement.

a. _______________ induction occurs when a magnet is placed in close proximity to a ferromagnetic material causing the material to also become magnetized.

b. _______________ induction is the action which causes electrons to flow in a conductor when the conductor cuts the lines of force in a magnetic field.

c. The amount of current induced into the conductor is determined by four factors (Faraday's law):

1) _______________ of the magnetic field

2) _______________ of the conductor with respect to the field

3) _______________ at which the conductor cuts the field

4) _______________ of the conductor in the field

d. Lenz' law states that the direction of the induced current must be such that its own magnetic field will _______________ the action that produced the induced current.

TEST

4. Complete the following statements related to the characteristics of induction by inserting the word(s) or letter that best completes each statement.

   a. ________________ is the physical property of a circuit or device which indicates an ability to oppose a change in current.

   b. Inductance may be defined as the ability to induce an EMF into a conductor when there is a change in ________________ ________________.

   c. The symbol for inductance is the letter ________________.

   d. The unit for measurement for inductance is the ________________.

   e. A Henry is the amount of inductance that induces an EMF of one volt into a conductor when the ________________ changes at the rate of one ampere per second.

   f. The henry is expressed symbolically with the letter ________________.

5. Select true statements concerning factors affecting inductors by placing an "X" in the blanks preceding the true statements.

   _____a. An inductor is a physical device consisting of a coil of wire usually wound on a core.

   _____b. The inductance of a coil varies as the square of the number of turns.

   _____c. Inductance of a coil may be decreased dramatically by winding the coil on a core of material that has a high permeability.

   _____d. Inductance varies inversely with the winding of the coil.

6. Select true statements related to power characteristics in an inductive circuit by placing an "X" in the blanks preceding the true statements.

   _____a. No power is dissipated in a pure inductance.

   _____b. Power dissipation in an RL circuit occurs in the resistance within the circuit.

   _____c. Since power is dissipated only in the resistance, it may be calculated using the standard power formulas.

TEST

7. Complete the following statements concerning characteristics of a transformer by inserting the word(s) which best complete each statement.

   a. The transformer is one use of the ________________ process.

   b. Different electrical devices require ________________ operating ________________. Transformers change these voltages to meet a specific need.

   c. Transformers have three basic parts: a primary conductor, a secondary conductor, and a ________________.

   d. When the windings on the primary side are decreased and the windings on the secondary side are increased, this is called a ________________ transformer.

   e. When the windings on the primary side are increased and the windings on the secondary side decreased, this is called a ________________ transformer.

   f. ________________ have a single winding that acts as a primary and secondary.

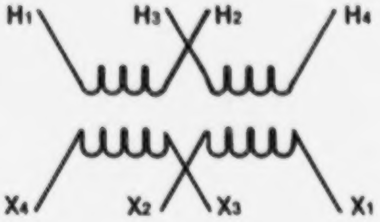
8. List the two classes of transformers.

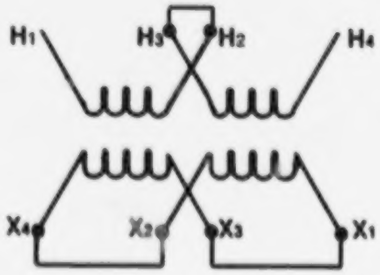
   a. ____

   b. ____

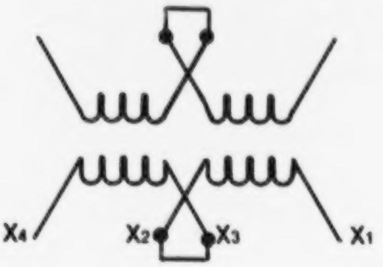
TEST

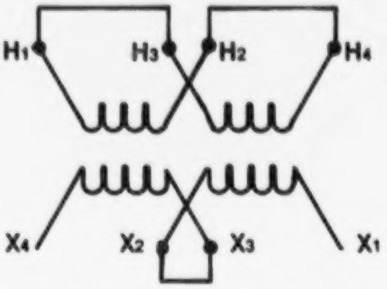
9. Identify transformer connections on a three-phase delta system.


H₁
H₃
H₂
H₄
X₄
X₂
X₃
X₁


H₁
H₃
H₂
H₄
X₄
X₂
X₃
X₁

a. ______________________________ b. ______________________________

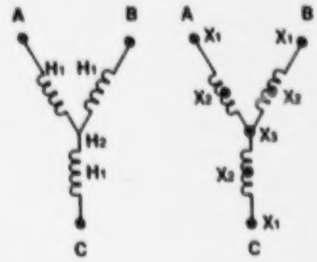


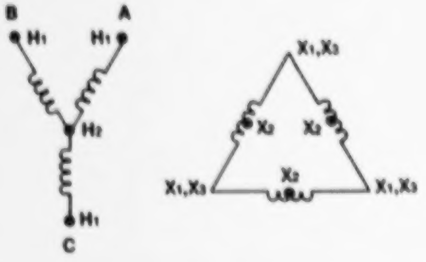

H₁
H₃
H₂
H₄
X₄
X₂
X₃
X₁

c. ______________________________ d. ______________________________

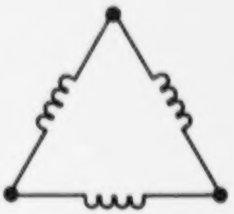
TEST

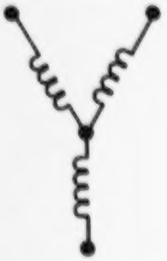
10. Identify other transformer connections found in electrical trades.


A
B
H_1
H_1
H_2
H_1
C
A
B
X_1
X_1
X_2
X_2
X_3
X_2
X_1
C

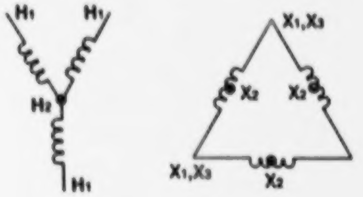

B
A
H_1
H_1
H_2
H_1
C
X_1,X_3
X_2
X_2
X_2
X_1,X_3
X_1,X_3

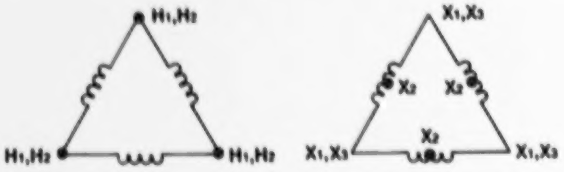
a. ______________________________ b. ______________________________





c. ______________________________ d. ______________________________


H_1
H_1
H_2
H_1
X_1,X_3
X_2
X_2
X_1,X_3
X_2


H_1,H_2
H_1,H_2
H_1,H_2
X_1,X_3
X_2
X_2
X_2
X_1,X_3
X_1,X_3

e. ______________________________ f. ______________________________

11. Complete the following statements concerning power in three-phase circuits by circling the word which best completes each statement.

    a. **(Wye, Delta)** — Voltage across each load member is full-line voltage; amperage in each member is______ × line amps or 1.732 × amps.

    b. **(Delta, Wye)** — Amperage in each member is full-line amperage; voltage across each member is______ × line volts or 1.732 × volts.

TEST

12. Select true statements concerning testing for polarity by placing an "X" in the blanks preceding the true statements.

_____a. When testing a transformer for polarity, there are two kinds of windings: additives and subtractives.

_____b. When testing a transformer for polarity, connect one test lead to the high voltage side and the other test lead to the low voltage tap directly under the high voltage tap.

_____c. If the meter reads the incoming voltage, it is a subtractive.

_____d. If the meter reads less than the incoming voltage, it is an additive.

_____e. When finding the taps for an additive transformer, the taps are usually opposite each other.

_____f. When finding the taps for a subtractive transformer the taps are usually directly under each other.

13. Complete the following statements related to the characteristics of capacitance by inserting the word(s) that best complete(s) each statement.

a. The property of a circuit or device which enables it to store electrical energy with an electrostatic field is called _______________ .

b. A device that is made to have a specific value of capacitance is called a _______________ .

c. A capacitor is a device constructed of two metal plates separated by a _______________ .

d. Capacitance of a capacitor is determined by three factors:

1) The _______________ of the metal plates.

2) The _______________ between the plates.

3) The type or nature of the _______________ .

e. The unit of capacitance is the _______________ .

f. One _______________ is the amount of capacitance which will store a charge of one coulomb when one volt of EMF is applied.

TEST

14. Select true statements concerning types, ratings, and common defects of capacitors by placing an "X" in the blanks preceding the true statements.

_____a. There are two basic types of capacitors: fixed value capacitors and variable capacitors.

_____b. Capacitors are classified by the type of dielectric used such as mica, ceramic, paper, and mylar.

_____c. Capacitors may be an electrolytic type.

_____d. Capacitors are rated according to value of capacitance.

_____e. Defects in capacitors are related to four common failures.

15. Complete the equations related to the characteristics of impedance in RC circuits by placing the correct symbols in the blanks.

a. Impedance Z = ________________

b. Z = ________________

c. R = ________________

d. X_L = ________________

16. Complete the following statements related to characteristics of impedance in RL circuits by inserting the word(s) that best completes each statement.

a. The total opposition to current flow offered by both the resistor and inductor in an RL circuit is called ________________ .

b. Impedance is expressed in ________________ .

c. The applied ________________ and the circuit ________________ may be used to determine the impedance according to Ohm's law.

d. The impedance of a series RL circuit also may be determined by vector summation of ________________ and the ________________ reactance.

TEST

17. Select true statements concerning characteristics of power in an AC circuit by placing an "X" in the blanks preceding the true statements.

    _____a. In an AC circuit, voltage and current are always in phase.

    _____b. The power or product of voltage and current must be multiplied by a power factor to determine the true power.

    _____c. By using a meter we can determine the true power in a circuit.

18. List three basic switching circuits used in electricity.

    a. ______________________________

    b. ______________________________

    c. ______________________________

(NOTE: If the following activities have not been accomplished, ask your instructor when they should be completed.)

19. Solve power factor problems. (Assignment Sheet #1)

20. Solve RC and RL circuit problems. (Assignment Sheet #2)

21. Draw a diagram of a single pole switch on a light. (Assignment Sheet #3)

22. Draw a diagram of two three-way switches on a light. (Assignment Sheet #4)

23. Draw a diagram of two three-way switches and a four-way switch on a light. (Assignment Sheet #5)

24. Demonstrate the ability to:

    a. Wire a single pole switch controlling a single lighting outlet with the supply line entering the switch box. (Job Sheet #1)

    b. Wire a single pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box. (Job Sheet #2)

    c. Wire a three-way switching situation with the supply entering a single lighting outlet. (Job Sheet #3)

    d. Wire a four-way switching situation with the supply entering the lighting outlet box. (Job Sheet #4)

AC CIRCUITS
UNIT X

ANSWERS TO TEST

1.

a.	11	e.	3	i.	12
b.	9	f.	10	j.	4
c.	2	g.	5	k.	8
d.	6	h.	7	l.	1

2. a, c, f

3. a. Magnetic
   b. Electromagnetic
   c. 1) Strength
      2) Speed
      3) Angle
      4) Length
   d. Oppose

4. a. Inductance
   b. Current flow
   c. L
   d. Henry
   e. Current
   f. H

5. a, b

6. a, b, c

7. a. Induction
   b. Different
   c. Metal core
   d. Step-up
   e. Step-down
   f. Autotransformers

8. a. Single phase
   b. Three-phase

ANSWERS TO TEST

9. a. Dual winding transformer
   b. Series primary and parallel secondary
   c. Series primary and series secondary
   d. Parallel primary and series secondary

10. a. Wye-wye
    b. Wye-delta
    c. Delta
    d. Wye
    e. Wye-delta four-wire system
    f. Delta-delta

11. a. Delta
    b. Wye

12. a, b

13. a. Capacitance
    b. Capacitor
    c. Dielectric
    d. 1) Area
       2) Spacing
       3) Dielectric
    e. Farad
    f. Farad

14. a, b, c, d, e

15. a. $\frac{E_a}{I_t}$

    b. $\sqrt{R^2 + X_L^2}$

    c. $\sqrt{Z^2 - X_L^2}$

    d. $\sqrt{Z^2 - R^2}$

16. a. Impedance
    b. Ohms
    c. Voltage, current
    d. Resistance, inductive

ANSWERS TO TEST

17. b, c

18. a. Single pole switch
    b. Three-way switch
    c. Four-way switch

19.-23. Evaluated to the satisfaction of the instructor

24. Performance skills evaluated to the satisfaction of the instructor

WIRING METHODS
UNIT XI

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify wiring methods and their common applications. Competencies will be demonstrated by completing the assignment sheet, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to wiring methods with their correct definitions.
2. Identify wiring methods found in electrical trades.
3. Match wiring methods with their common applications.
4. Reference the National Electrical Code to identify uses of wiring methods. (Assignment Sheet #1)
5. Demonstrate the ability to:
    a. Install a set screw conduit fitting. (Job Sheet #1)
    b. Install a compression type conduit fitting. (Job Sheet #2)
    c. Braid the ground conductor of a service entrance cable. (Job Sheet #3)
    d. Install an ENT coupling and connector on ENT conduit. (Job Sheet #4)

WIRING METHODS
UNIT XI

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Provide students with objective sheet.

C. Discuss unit and specific objectives.

D. Provide students with information and assignment sheets.

E. Discuss information and assignment sheets.

F. Provide students with job sheets.

G. Discuss and demonstrate the procedures outlined in the job sheets.

H. Integrate the following activities throughout the teaching of this unit:

1. Take students on a field trip to a local supply house.
2. Invite local inspector to talk to class about various wiring methods.
3. Have local journeyman demonstrate wiring methods.
4. Have students report on articles dealing with wiring methods.
5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *National Electrical Code, 1987.* Quincy, MA: National Fire Protection Association, 1986.

B. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

WIRING METHODS
UNIT XI

INFORMATION SHEET

I. **Terms and definitions**

A. Cable — A factory assembly of two or more insulated and uninsulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material

B. Equipment — A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation

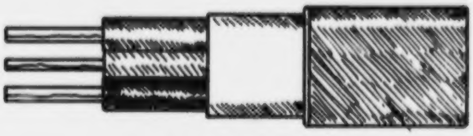
C. Exposed (as applied to wiring methods) — On or attached to the surface or behind panels designed to allow access

D. Fitting — An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function

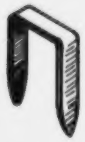
E. Premises wiring (system) — That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment

II. **Wiring methods found in electrical trades**

A. Nonmetallic sheathed cable (Romex)



NM Cable

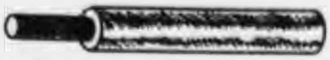


Staple

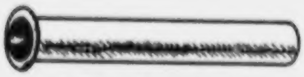
Connector

INFORMATION SHEET

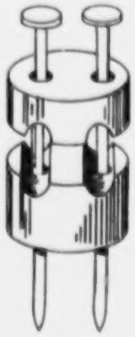
B. Concealed knob-and-tube wiring



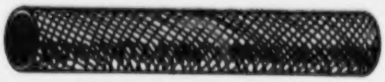
Insulated Conductor



Porcelain Tube

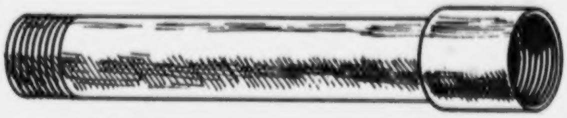


Knob

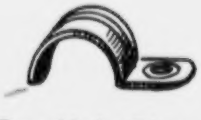


Braided Loom

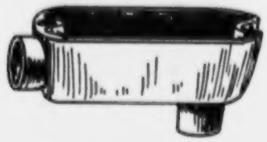
C. Rigid metal conduit



Metal Conduit and Coupling



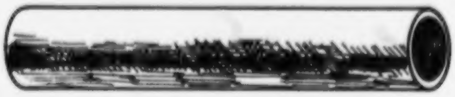
One-Hole Strap



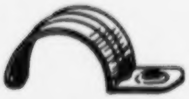
Conduit Body

INFORMATION SHEET

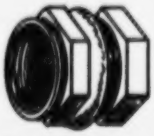
D. Electrical metallic tubing



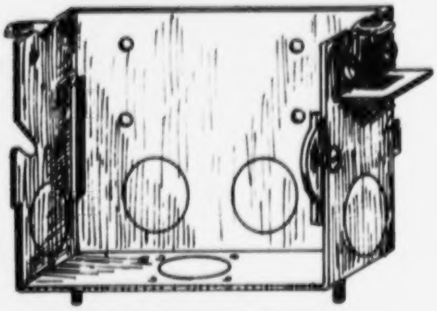
Electrical Metallic Conduit



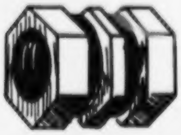
One-Hole Strap



EMT Connector

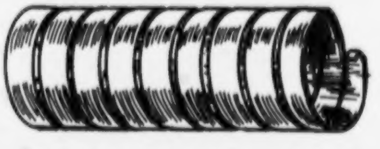


Device Box for Conduit

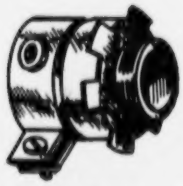


EMT Coupling

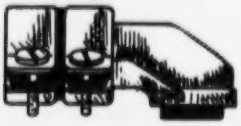
E. Flexible metal conduit



Flexible Metal Conduit



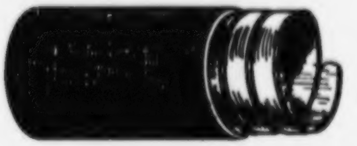
Straight Connector



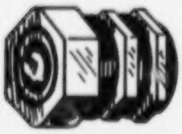
90° Connector

INFORMATION SHEET

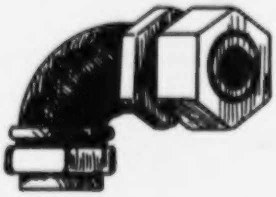
F. Liquid tight flexible metal conduit



Liquid Tight Flexible Metal Conduit

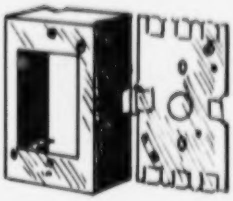


Liquid Tight Connector

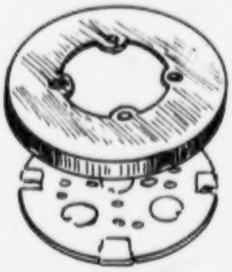


90° Liquid Tight Connector

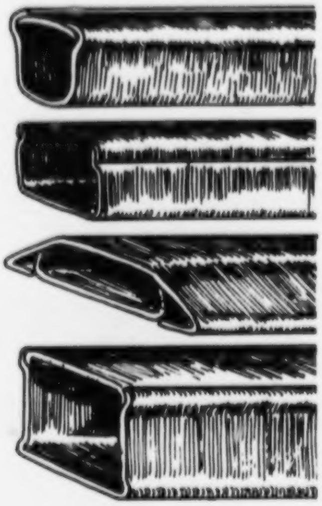
G. Surface raceways and boxes



Surface Device Box



Surface Lighting Outlet

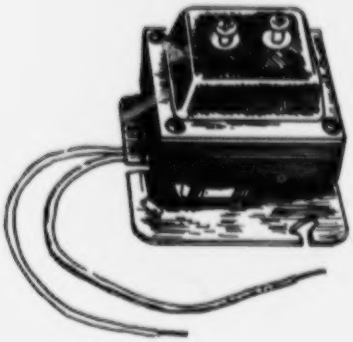


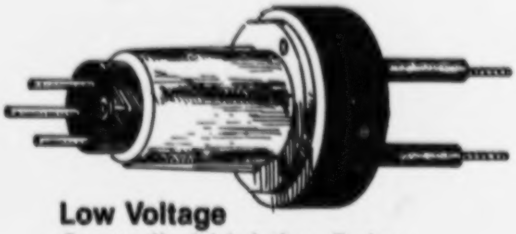
Surface Raceways

INFORMATION SHEET

H. Low voltage devices

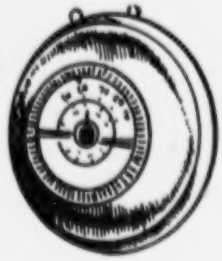
Transformer (Box Mount)

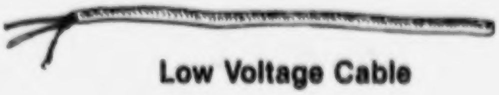




Low Voltage Controlled Lighting Relay

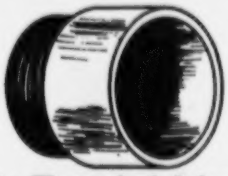
Thermostat



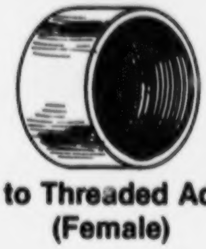


Low Voltage Cable

I. PVC fittings and connections

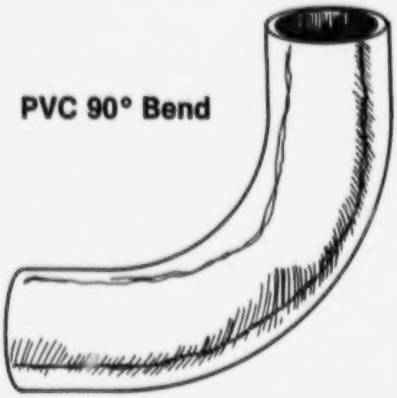


PVC to Threaded Adaptor (Male)



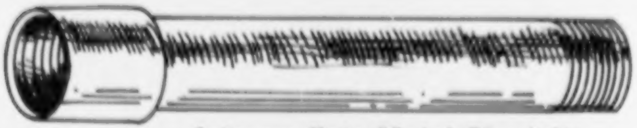
PVC to Threaded Adaptor (Female)

PVC 90° Bend

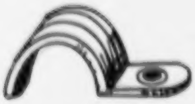


INFORMATION SHEET

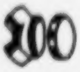
J. Intermediate metal conduit



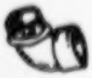
Intermediate Metal Conduit



Single-Hole Strap

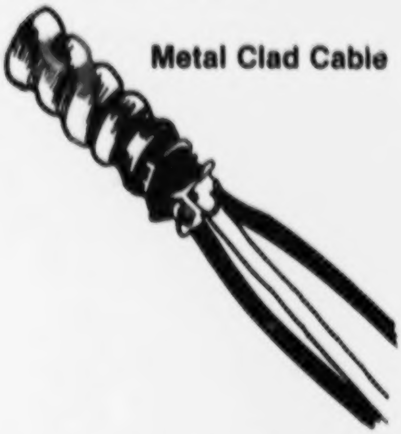


Capped Ell

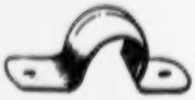


Threaded Ell

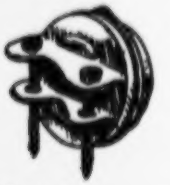
K. Metal clad cable



Metal Clad Cable

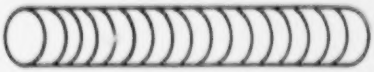


Two-Hole Strap

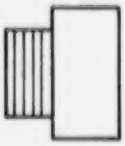


Metal Clad Connector

L. Electrical nonmetallic tubing (ENT)



ENT



Connector

Coupling

INFORMATION SHEET

III. **Wiring methods and their common applications**

A. Cable

1. Nonmetallic sheathed cable (NEC Art: 336)

a. General residential rough-in

b. Circuit extensions in existing dwellings

(NOTE: Nearly all the premises wiring in most new residential homes is done with NMB cable.)

2. Underground feeder and branch circuit cable (UF) — Direct burial for yard lights or extensions

B. Concealed knob-and-tube wiring (NEC Art: 324)

1. Extensions of existing installations

2. Elsewhere by special permission

C. Rigid metal conduit (NEC Art: 346)

1. Through eave service masts

2. Underground circuit extension

3. In concrete walls, floors, or ceilings

(NOTE: Wiring in poured basement walls, ceilings and floors is usually done with rigid metal conduit.)

4. Underground service riser

5. Commercial and industrial locations

6. Hazardous locations

D. Electrical metallic tubing (NEC Art: 348)

1. Service raceway

(NOTE: EMT is not suitable for installations going through an eave.)

2. Protecting grounding electrode conductor

3. Commercial and industrial locations

E. Flexible metal conduit (NEC Art: 350)

1. Connecting recessed lighting fixtures

2. Enclosing motor leads

INFORMATION SHEET

F. Liquid tight flexible metal conduit (NEC Art: 351)

   1. Connecting air conditioning condensers to disconnects
   2. Enclosing motor leads needing protection from liquids and vapors

G. Surface raceways (NEC Art: 352)

   1. Interior circuit extensions where concealed work is not necessary or not possible
   2. On interior concrete surfaces

H. Low voltage (NEC Art: 725)

   1. Chime circuits
   2. Intercom wiring
   3. Thermostat circuits
   4. Lighting control

I. Electrical nonmetallic tubing (NEC Art: 331)

   1. Locations subject to severe corrosive influences
   2. Suspended ceilings
   3. Concealed within walls

J. Intermediate metal conduit (NEC Art: 345)

   1. Lighter weight and a thinner wall than ridge
   2. May be used in all atmospheric conditions
   3. Hazardous locations
   4. Underground circuits

K. Metal clad cable (NEC Art: 334)

   1. Services
   2. Feeders
   3. Branch circuits
   4. Power, lighting and signal circuits

WIRING METHODS
UNIT XI

ASSIGNMENT SHEET #1 — REFERENCE THE NATIONAL ELECTRICAL CODE TO IDENTIFY USES OF WIRING METHODS

NAME ______________________________ SCORE ______________

Directions: Using the National Electrical Code, list the uses for the following wiring methods and the specific locations where they are found in the code.

A. Flexible metal conduit: ______________________________

____

____

____

B. Electrical metallic tubing: ______________________________

____

____

____

C. Rigid metal conduit: ______________________________

____

____

____

D. Liquid tight flexible metal conduit: ______________________________

____

____

____

E. Nonmetallic sheathed cable: ______________________________

____

____

____

ASSIGNMENT SHEET #1

F. Electrical nonmetallic tubing: ______________________________

____

____

____

G. Intermediate metal conduit: ______________________________

____

____

____

H. Metal clad cable: ______________________________

____

____

____

I. Concealed knob-and-tube wiring: ______________________________

____

____

____

J. Surface raceways: ______________________________

____

____

____

WIRING METHODS
UNIT XI

ANSWERS TO ASSIGNMENT SHEET #1

A. Art: 350-2

B. Art: 348-1

C. Art: 346-1

D. Art: 351-4

E. Art: 336-3

F. Art: 331-3

G. Art: 345-3

H. Art: 334-3

I. Art: 324-3

J. Art: 352-1

WIRING METHODS
UNIT XI

JOB SHEET #1 — INSTALL A SET SCREW CONDUIT FITTING

A. Equipment and materials needed

1. ½" set screw fitting

   (NOTE: For this job sheet either a connector or coupling is suitable.)

2. ½" conduit
3. Screwdriver
4. Safety glasses

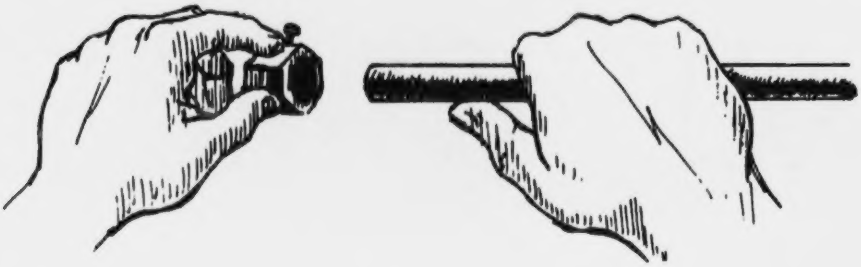
B. Procedure

1. Put on safety glasses.
2. Gather equipment and materials.
3. Check conduit to see if it is reamed and has a square cut end.
4. Pick up the connector.

   (NOTE: Hold it in the most skillful of your hands. Right-handed person should hold in right hand.)

5. Pick up the conduit with other hand.
6. Slide the connector onto the conduit till it bottoms. (Figure 1)

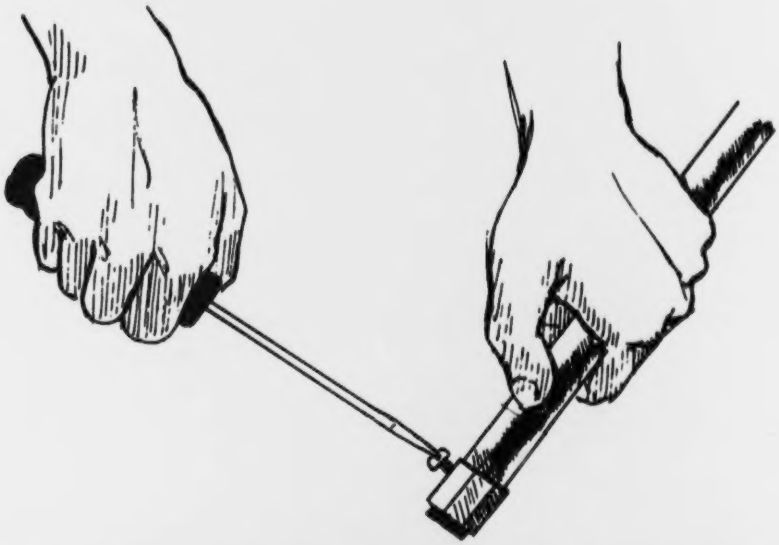
FIGURE 1



JOB SHEET #1

7. Secure screw with screwdriver. (Figure 2)

FIGURE 2



(CAUTION: Keep hand holding conduit in position away from the connector to avoid getting jabbed if the screwdriver should slip. Don't overtighten set screw.)

(NOTE: During this operation the least skillful of your hands should be involved only in the holding of the conduit after step 4. This nonshifting approach should save time by saving hand movement.)

7. Clean work area and put away all equipment and materials.

WIRING METHODS
UNIT XI

JOB SHEET #2 — INSTALL A COMPRESSION TYPE CONDUIT FITTING

A. Equipment and materials needed

1. ½" compression type fitting

   (NOTE: For the purpose of this job sheet either a connector or coupling may be used.)

2. ½" conduit

3. Two pairs groove joint pliers

   (NOTE: Two adjustable wrenches or one wrench and one pair of pliers will also suffice.)

4. Safety glasses

B. Procedure

1. Put on safety glasses.

2. Gather equipment and materials.

3. Check conduit to see if it is reamed and has straight even ends.

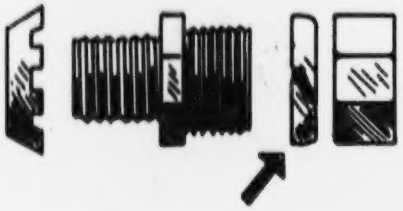
4. Pick up connector.

   (NOTE: Hold in least skillful hand and use most skillful for next two operations to avoid handshifting.)

5. Loosen compression nut.

   (NOTE: Don't completely remove nut. Look inside and be sure compression ring is inside the fitting. See Figure 1.)

FIGURE 1

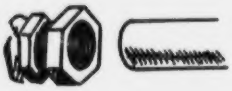


JOB SHEET #2

6. Slide fitting onto conduit (Figure 2)

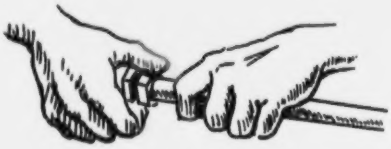
   (NOTE: The conduit should make a click that will also be felt when it bottoms.)

   FIGURE 2



7. Tighten compression nut by hand. (Figure 3)

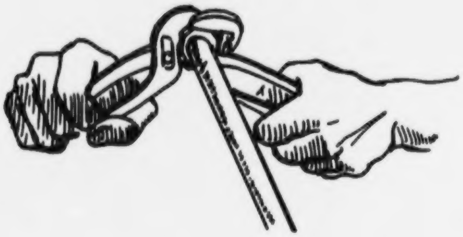
   FIGURE 3



8. Tighten fitting with pliers or adjustable wrenches. (Figure 4)

   (CAUTION: Overtightening the smaller trade size fittings can cause threads to strip or nuts to crack.)

   FIGURE 4



9. Clean work area and put away all equipment and materials.

WIRING METHODS
UNIT XI

JOB SHEET #3 — BRAID THE GROUND CONDUCTOR OF A SERVICE ENTRANCE CABLE

A. Equipment and materials needed

1. SE cable
2. Knife
3. Safety glasses
4. Lineman's pliers

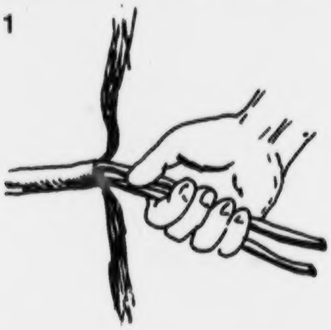
B. Procedure

1. Put on safety glasses.
2. Gather equipment and materials.
3. Strip off a length of the outer sheath.

   (NOTE: Always use safe working practices when using a knife.)

4. Separate the ground strands into two separate groups. (Figure 1)

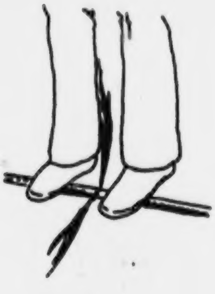
   FIGURE 1



5. Stand on the cable. (Figure 2)

   (NOTE: Be sure the conductors are not on rocks or other materials that could damage the insulation while you have them secured.)

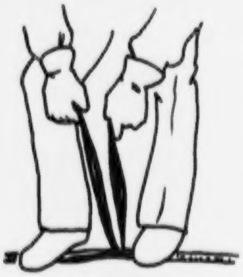
   FIGURE 2



JOB SHEET #3

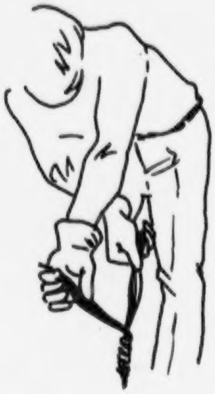
6. Bend over and grasp the separated neutral. (Figure 3)

FIGURE 3



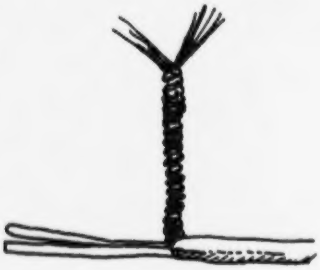
7. Twist the conductor together while pulling upward. (Figure 4)

FIGURE 4



8. Braid as far as possible by hand. (Figure 5)

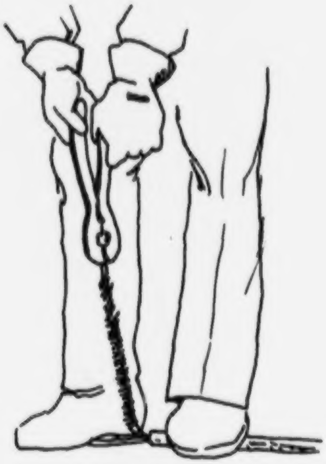
FIGURE 5



JOB SHEET #3

9. Twist with pliers until braid is continuous and uniform. (Figure 6)

FIGURE 6



10. Have instructor evaluate work.

11. Clean work area and put away all equipment and materials.

WIRING METHODS
UNIT XI

JOB SHEET #4 — INSTALL AN ENT COUPLING AND CONNECTOR ON ENT CONDUIT

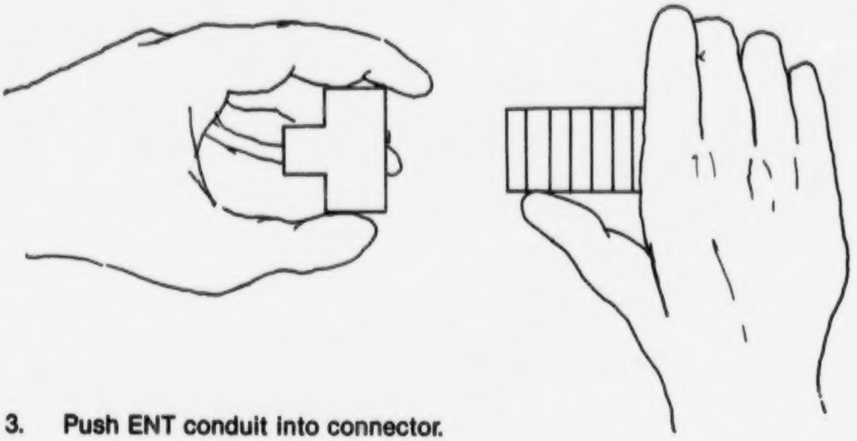
A. Equipment and materials needed

1. 1′ × 1/2″ ENT conduit
2. 1/2″ ENT connector
3. 1/2″ ENT coupling
4. 1 can PVC glue
5. Hook knife

B. Procedure

1. Clean ENT conduit.
2. Apply PVC on end of ENT. (Figure 1)

FIGURE 1



3. Push ENT conduit into connector.
4. Hold tight until PVC glue dries.
5. Repeat process for coupling.
6. Have instructor evaluate work.
7. Clean work area and put away all equipment and materials.

WIRING METHODS
UNIT XI

PRACTICAL TEST
JOB SHEET #1 — INSTALL A SET SCREW CONDUIT FITTING

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Checked conduit for reaming and square cut.	______	______
3. Positioned connector for full bottoming on pipe.	______	______
4. Secured screw.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Connector bottomed on pipe	4	3	2	1
Set screw tight	4	3	2	1
Quality of deburring	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WIRING METHODS
UNIT XI

PRACTICAL TEST
JOB SHEET #2 — INSTALL A COMPRESSION TYPE CONDUIT FITTING

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Checked conduit for reaming and square cut.	______	______
3. Checked connector to see if it has bottomed out.	______	______
4. Tightened compression nut.	______	______
5. Tightened fitting.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Pipe bottomed to connector	4	3	2	1
Tightness of compression nut	4	3	2	1
Tightness of fitting	4	3	2	1
Quality of deburring	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WIRING METHODS
UNIT XI

PRACTICAL TEST
JOB SHEET #3 — BRAID THE GROUND CONDUCTOR OF A SERVICE ENTRANCE CABLE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Separated ground strands into two groups.	______	______
3. Twisted conductor together.	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Strands are twisted together properly	4	3	2	1
Braid is continuous and uniform	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

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WIRING METHODS
UNIT XI

PRACTICAL TEST
JOB SHEET #4 — INSTALL AN ENT COUPLING AND CONNECTOR ON ENT CONDUIT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned ENT conduit.	______	______
3. PVC glue is applied properly.	______	______
4. ENT connector installed correctly.	______	______
5. ENT coupling installed correctly.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Coupling and connector tightly glued	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WIRING METHODS
UNIT XI

TEST

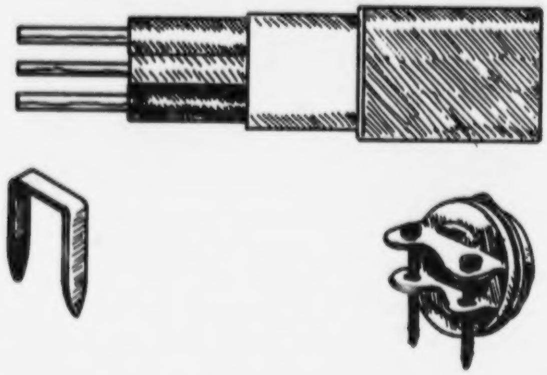
NAME ______________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

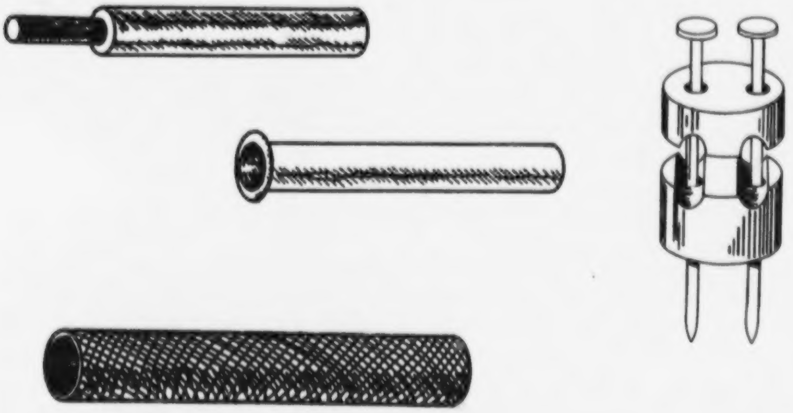
_____a.	That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, both permanently and temporarily installed which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment	1. Exposed 2. Equipment 3. Cable 4. Premises wiring 5. Fitting
_____b.	An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function	
_____c.	A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation	
_____d.	On or attached to the surface or behind panels designed to allow access	
_____e.	A factory assembly to two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, non-metallic material	

TEST

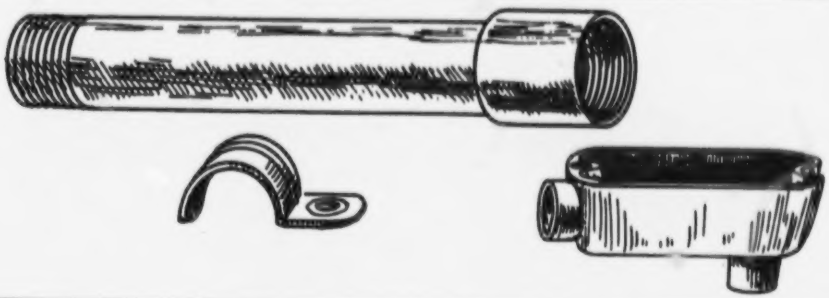
2. Identify the following wiring methods found in electrical trades.



a. ______________________________

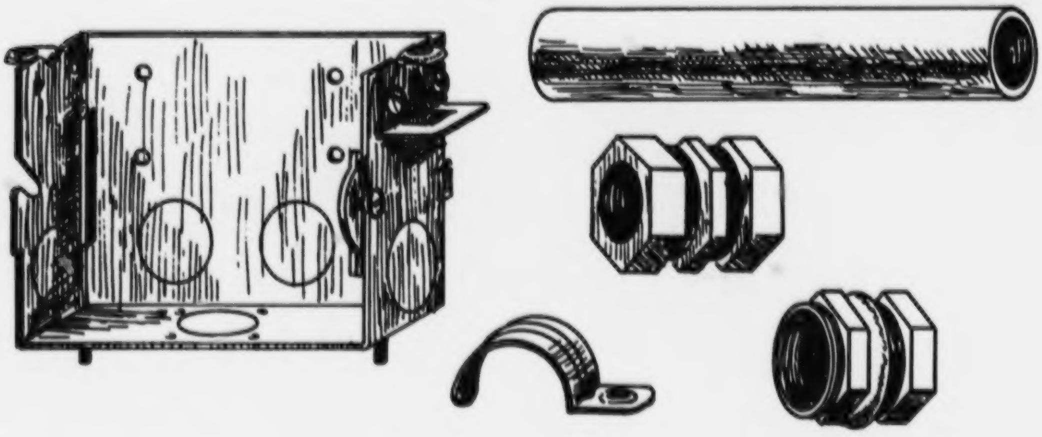


b. ______________________________

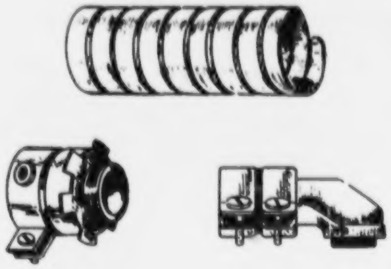


c. ______________________________

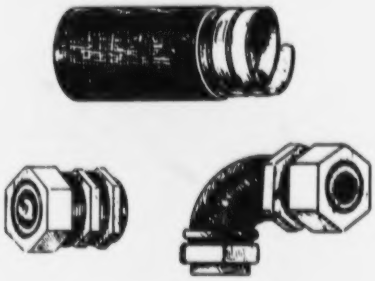
TEST



d. ____

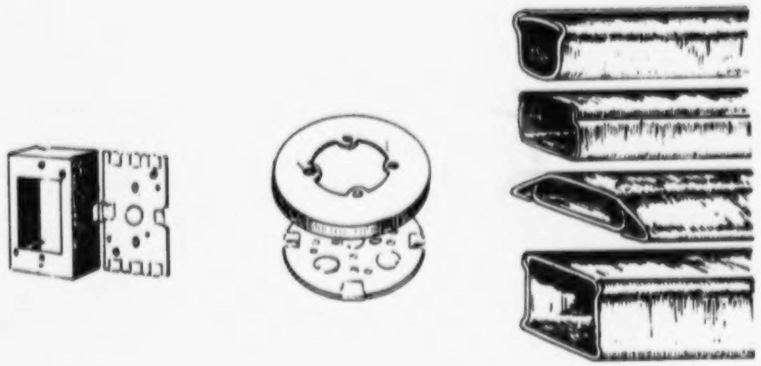


e. ____

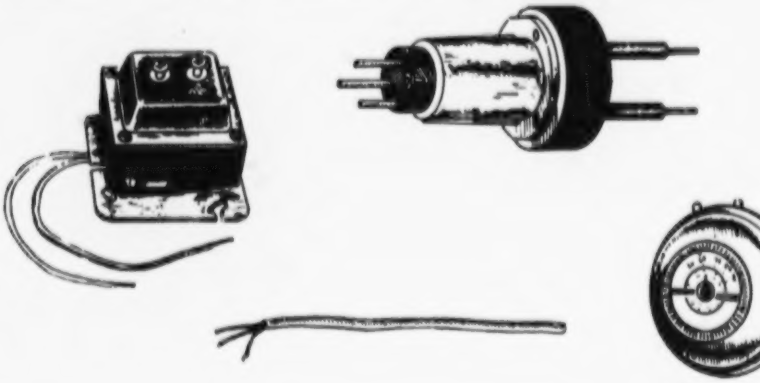


f. ____

TEST



g. ______________________________



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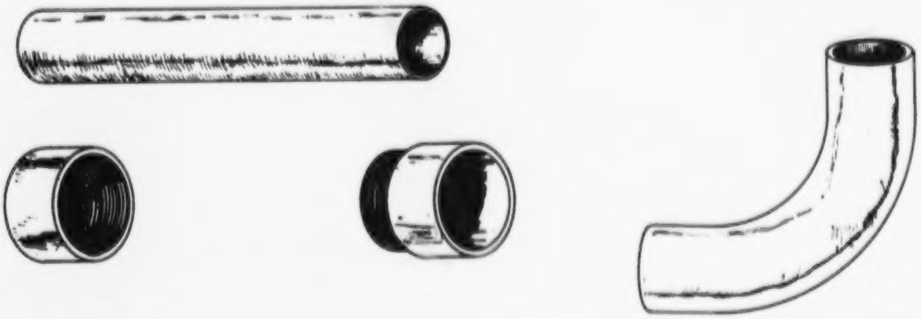
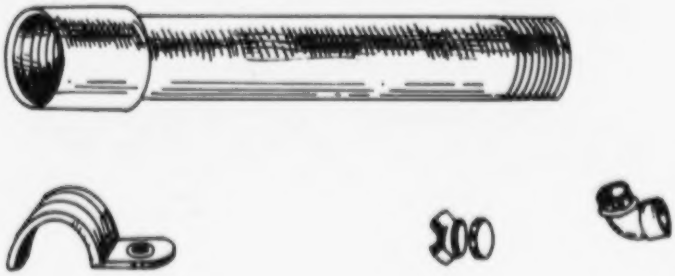
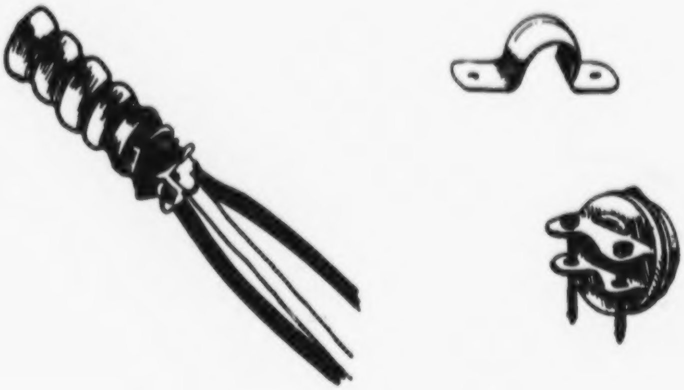


i. ______________________________

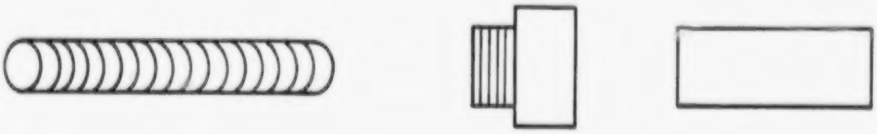
TEST



j. ______________________________



k. ______________________________



l. ______________________________

TEST

3. Match the wiring methods on the right with their common applications.

_____a.
1) Nonmetallic sheathed cable
    a) General residential rough-in
    b) Circuit extensions in existing dwellings
2) Underground feeder and branch circuit cable (UF)—Direct burial for yard lights or extensions

_____b.
1) Extensions of existing installations
2) Elsewhere by special permission

_____c.
1) Through eave service masts
2) Underground circuit extension
3) In concrete wall, floors, or ceilings
4) Underground service riser
5) Commercial and industrial locations
6) Hazardous locations

_____d.
1) Service raceway
2) Protecting grounding electrode conductor
3) Commercial and industrial locations

_____e.
1) Connecting recessed lighting fixtures
2) Enclosing motor leads

_____f.
1) Connecting air conditioning condensers to disconnects
2) Enclosing motor leads needing protection from liquids and vapors

_____g.
1) Interior circuit extensions where concealed work is not necessary or not possible
2) On interior concrete surfaces

_____h.
1) Chime circuits
2) Intercom wiring
3) Thermostat circuits
4) Lighting control

_____i.
1) Locations subject to severe corrosive influences
2) Suspended ceilings
3) Concealed within walls and floors

_____j.
1) Services
2) Feeders
3) Branch circuits
4) Power, lighting, and signal circuits

1. Liquid tight flexible metal conduit
2. Electrical metallic tubing
3. Cable
4. Low voltage
5. Concealed knob-and-tube wiring
6. Rigid metal conduit
7. Surface raceways
8. Flexible metal conduit
9. Electrical nonmetallic tubing
10. Intermediate metal conduit
11. Metal clad cable

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

4. Reference the National Electrical Code to identify uses of wiring methods. (Assignment Sheet #1)

5. Demonstrate the ability to:

    a. Install a set screw conduit fitting. (Job Sheet #1)

    b. Install a compression type conduit fitting. (Job Sheet #2)

    c. Braid the neutral conductor of a service entrance cable. (Job Sheet #3)

    d. Install an ENT coupling and connector on ENT conduit. (Job Sheet #4)

WIRING METHODS
UNIT XI

ANSWERS TO TEST

1. a. 4
   b. 5
   c. 2
   d. 1
   e. 3

2. a. Nonmetallic sheathed cable (Romex)
   b. Concealed knob-and-tube wiring
   c. Rigid metal conduit
   d. Electrical metallic tubing (EMT)
   e. Flexible metal conduit
   f. Liquid tight flexible metal conduit
   g. Surface raceways
   h. Low voltage
   i. PVC (polyvinyl chloride)
   j. Intermediate metal conduit
   k. Metal clad cable
   l. Electrical nonmetallic tubing

3. a. 3
   b. 5
   c. 6
   d. 2
   e. 8
   f. 1
   g. 7
   h. 4
   i. 9
   j. 10

4. Evaluated to the satisfaction of the instructor

5. Performance skills evaluated to the satisfaction of the instructor

CONDUCTORS
UNIT XII

UNIT OBJECTIVE

After completion of this unit, the student should be able to select and install proper conductors. Competencies will be demonstrated by completing the assignment sheets, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to conductors with their correct definitions.
2. List six factors that determine type and size of conductors.
3. Select from a list characteristics of good connections.
4. Identify types of connectors, terminals, and lugs.
5. Complete a chart related to types of insulation.
6. List three conductors commonly found in electrical wiring.
7. Match types of cables found in the electrical field with their correct uses.
8. Select true statements concerning cords and their conductors.
9. Complete statements concerning cables and their conductors.
10. Select conductors for various ampacities and temperatures. (Assignment Sheet #1)
11. Calculate ampacity of conductors, given number of conductors in raceway. (Assignment Sheet #2)

OBJECTIVE SHEET

12. Calculate ampacity and conductor sizes for specific types of loads. (Assignment Sheet #3)
13. Select cords for various applications. (Assignment Sheet #4)
14. Select proper types of insulation. (Assignment Sheet #5)
15. Demonstrate the ability to:
    a. Install cord on utilization equipment. (Job Sheet #1)
    b. Use a fish tape to install wire in conduit. (Job Sheet #2)
    c. Prepare an aluminum conductor for termination. (Job Sheet #3)

CONDUCTORS
UNIT XII

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparency from the transparency master included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparency to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

  1. Construct a display of conductors showing types and sizes.
  2. Construct a display of cables and cords showing types and sizes.
  3. Invite local supplier to demonstrate termination methods.
  4. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

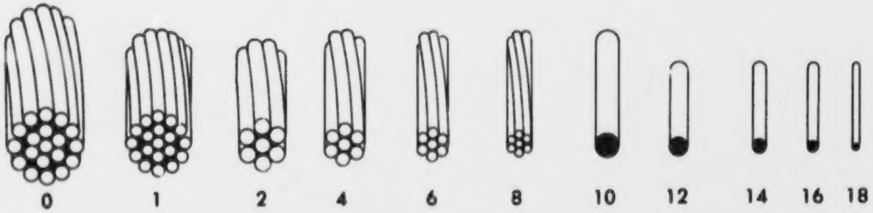
A. Clidera, Robert and Kenneth Sharpe. *Construction Wiring*. Albany, NY: Delmar Publishers, 1982.

B. *National Electrical Code, 1987*. Quincy, MA: National Fire Protection Association, 1986.

C. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

D. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

Size of Conductors


0
1
2
4
6
8
10
12
14
16
18

Actual Diameters of
Typical Sizes of Electric Wires Without the Insulation

CONDUCTORS
UNIT XII

INFORMATION SHEET

I. **Terms and definitions**

A. Aluminum wire — Conductor made of aluminum

B. Ampacity — The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

C. AWG — American Wire Gauge

D. Bare conductor — A conductor having no covering or electrical insulation

E. Cable — Two or more conductors grouped together in an overall covering

F. Circular mils — The diameter of a conductor in thousandths of inches multiplied times itself

G. Color coding — Assigning colors to conductors based on their uses

EXAMPLES: Neutral conductor (white), equipment ground wire (green)

H. Copper-clad aluminum — Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

I. Copper wire — Conductor made of copper

J. Cord — Two or more stranded conductors grouped together in a flexible covering

K. Covered — Conductor encased within material of composition and thickness not recognized by the *National Electrical Code* as electrical insulation

L. Fish tape — Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

M. Grounded conductor — A circuit conductor that is intentionally connected to the earth or some conductor that serves in place of the earth

(NOTE: An insulated grounded conductor of No. 6 or smaller shall be identified by continuous white or natural gray outer finish along its entire length. Insulated grounded conductors larger than No. 6 will be identified by a continuous white or natural gray outer finish or at the time of installation by a distinctive white marking at its termination.)

N. Grounding conductor — Connects equipment or wiring circuit grounded conductor to a grounding electrode

(NOTE: Equipment grounding conductors will be identifiable by a continuous green color or green with one or more yellow stripes unless it is bare.)

INFORMATION SHEET

O. Insulated — Conductor encased within material of composition and thickness recognized by the *National Electrical Code* as electrical insulation

P. Mil — One thousandth of an inch

Q. Type letter — Identification accepted by the trade in referring to the particular types of insulations

II. Factors that determine type and size of conductors

(NOTE: NEC Table 310-16 covers sizing for most general wiring for 60°C to 90°C temperature ranges.)

A. Full load amperes

B. Number of conductors in raceway

(NOTE: See NEC Table 310-16, Note 8.)

C. Type of load to be served

EXAMPLES: NEC 424-3(a) and (b) — Fixed electric space-heating requires conductors for not less than 125 percent of full load.

NEC 430-22 — Single motors require conductors for 125 percent of full-load ampacity.

NEC 430-24 — Two or more motors require conductors for 125 percent of the largest motor, plus sum of full-load ampacity of all smaller motors.

NEC 430-32 — All continuous motor loads require conductors of at least 115 percent to 125 percent ampacity.

D. Length of run

(NOTE: See NEC Table 310-16, Note 12 and NEC Articles 210-19 and 215-2.)

E. Ambient temperature encountered

(NOTE: See NEC Tables 310-16 and 310-18.)

EXAMPLES: Rooftop temperatures in summer approach the water boiling point of 100°C or 212°F.

Boiler and furnace rooms may reach temperatures near 100°C.

F. Voltage

(NOTE: Most conductors for general use are rated for 600 volts. Higher voltage ratings are generally specified on a special order.)

INFORMATION SHEET

III. Characteristics of good connections

A. Are clean

B. Are tight

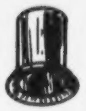
C. Are strong

D. Provide full contact

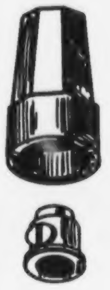
E. Use approved devices and oxidation inhibitors when connecting copper to aluminum

IV. Types of connectors, terminals, and lugs

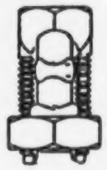
A. Crimp sleeve connector



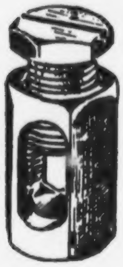
B. Set screw lug



C. Split-bolt lug



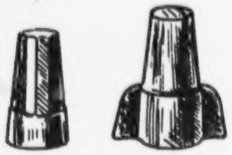
D. Service-entrance lug



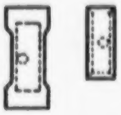
INFORMATION SHEET

E. Wire-nut lugs

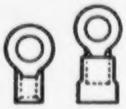
(NOTE: These are available in many configurations and sizes.)



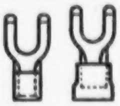
F. Crimp-type butt connectors



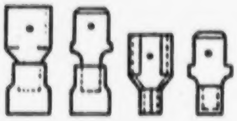
G. Ring lugs



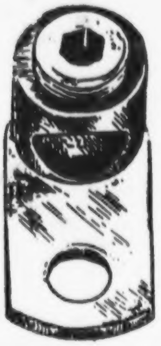
H. Spade connectors



I. Quick disconnect connectors

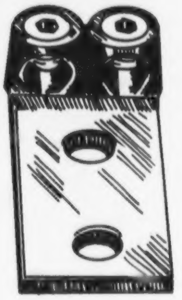


J. Single terminal



K. Twin or double terminal

(NOTE: These are available in many configurations.)



INFORMATION SHEET

V. Types of insulation

Insulation Name	Code Letters	Application	Characteristics
Thermoplastic	T	Dry locations	Flame retardant
Moisture-resistant thermoplastic	TW	Dry and wet locations	Flame retardant, moisture resistant
Heat-resistant thermoplastic	THHN	Dry locations	Flame retardant, heat resistant
Moisture-, heat-, and oil-resistant thermoplastic	MTW	Machine tool wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670) Machine tool wiring in dry locations as permitted in NFPA Standard No. 79 (See Article 670)	Flame retardant, moisture, heat, and oil resistant
Moisture- and heat-resistant thermoplastic	THW	Dry and wet locations Special applications within electric discharge lighting equipment; limited to 1,000 open-circuit volts or less (size 14-8 only as permitted in Section 410-31)	Flame retardant, moisture and heat resistant
Moisture- and heat-resistant thermoplastic	THWN	Dry and wet locations	Flame retardant, moisture and heat resistant

INFORMATION SHEET

VI. Conductors commonly found in electrical wiring

- A. Copper
- B. Aluminum
- C. Copper-clad aluminum

VII. Types of cables found in the electrical field and their uses

- A. Nonmetallic-sheathed cable (NM)

  (NOTE: Refer to NEC Article 336.)

  - 1. Dry locations
  - 2. Majority of residential interior wiring

    (NOTE: The insulated conductors shall be one of the types listed in Table 310-13 which is suitable for branch circuit wiring or one which is identified for use in these cables. Conductors shall be rated 90°C (194°F). The ampacity of types NM and NMC cable shall be that of 60°C (140°F) conductors and shall comply with section 310-15. Type NMB is rated 90°C.)

- B. Underground feeder cable (UF)

  (NOTE: Refer to NEC Article 339.)

  - 1. Dry and wet locations
  - 2. Suitable for burial

- C. Service entrance cable (SE)

  (NOTE: Refer to NEC Article 338.)

  - 1. Dry or wet locations
  - 2. Service entrance conductors where applicable

- D. Armored cable (AC)

  (NOTE: Refer to NEC Article 333.)

  - 1. Dry locations
  - 2. Branch circuits and feeders in both exposed and concealed work

INFORMATION SHEET

E. Mineral-insulated cable (MI)

(NOTE: Refer to NEC Article 330.)

1. Dry and wet locations

2. Service feeders and branch circuits

F. Power and control tray cable (TC) — Power, lighting, control, signal, and communication circuits

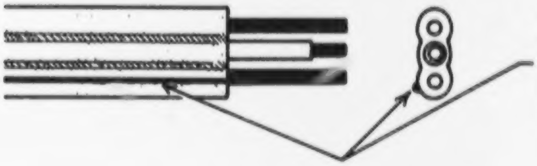
(NOTE: Refer to NEC Article 340.)

VIII. Cords and their conductors

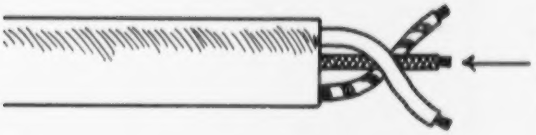
(NOTE: Refer to NEC Article 400.)

A. Cords used in a grounded system must have an identified grounded conductor.

(NOTE: **Grounded-conductor identification** (a) through (f) describes acceptable methods for identifying grounded conductors.)



A ridge is used on many flat cords to identify the grounded conductor.

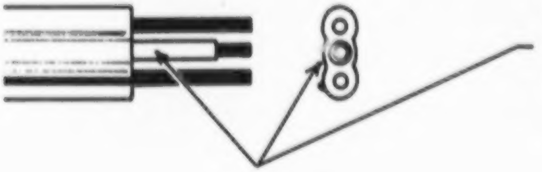


A white or natural gray braid or molded insulation is often used on round cords.

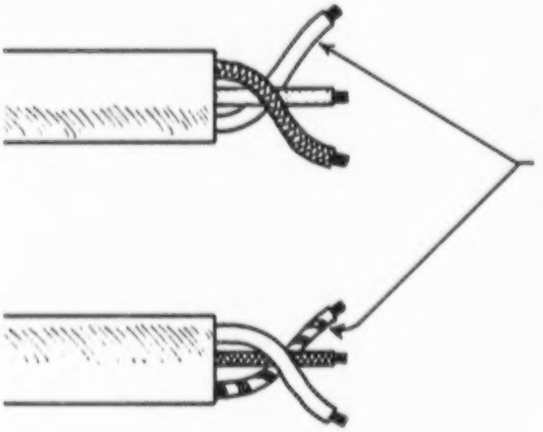
INFORMATION SHEET

B. Cords which have a conductor with green or green with yellow striped insulation shall use that conductor for grounding purposes only.

(NOTE: Refer to NEC Article 400-23.)



A central conductor with green insulation is often included in flat cords as a grounded conductor.



A green or green and yellow striped braid or molded insulation is often used in round cords to identify a grounding conductor.

C. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors.

D. Cords should be used within their amp and insulation rating or classification.

(NOTE: Refer to NEC Table 400-5.)

IX. **Cables and their conductors**

A. When used in a grounded system an identified grounded conductor (white or natural gray) must be in the cable.

B. A bare or green conductor is always used as the equipment grounding conductor.

C. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors.

D. Cables should be used within their amp and condition rating.

CONDUCTORS
UNIT XII

ASSIGNMENT SHEET #1 — SELECT CONDUCTORS FOR VARIOUS AMPACITIES AND TEMPERATURES

NAME ______________________________ SCORE ______________

The electrical worker must be able to select proper conductors for various ampacities and temperatures. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions: Select conductors for various ampacities and temperatures. Use the *National Electrical Code*, Tables 310-16 to 310-31 for not more than three conductors in a raceway. Use the temperature rating column that is the same or the next higher rating than the required temperature, then select the size conductor for the required or next higher ampacity. Refer only to the sizes given for copper wiring.

EXAMPLES: What wire size is required for a load of 55 amperes at 30°C? The answer is #6 AWG. This is obtained by referring to the 60°C column because the required temperature is not above 60°C. You must then check the ampacity correction factor. Since the temperature is not over 30°C you may use the amperage listed in Table 310-16 of 55 amperes for #6.

What wire size is required for a load of 25 amperes at 68°F? The answer is #10 AWG. Although the chart under the 167°F column shows that #12 AWG is acceptable for 25 amperes at this temperature, the obelisk(†) indicates a note below the table. According to the note, the overcurrent protection for each type of conductor shown shall not exceed 20 amperes for #12 AWG wire. Thus, you will need to use the next heavier gauge, #10 AWG, which provides overcurrent protection up to 30 amperes.

ASSIGNMENT SHEET #1

Amperes	Temperature	Wire Size Per *NEC* 310-16 to 310-31
20	65°C	A. ________________
35	75°C	B. ________________
37	85°C	C. ________________
110	87°C	D. ________________
110	65°C	E. ________________
232	75°C	F. ________________
400	85°C	G. ________________
540	60°C	H. ________________
67	65°C	I. ________________
83	75°C	J. ________________
190	70°C	K. ________________

CONDUCTORS
UNIT XII

ASSIGNMENT SHEET #2 — CALCULATE AMPACITY OF CONDUCTORS, GIVEN NUMBER OF CONDUCTORS IN RACEWAY

NAME ______________________________ SCORE ______________

The electrical worker must be able to calculate the ampacity of conductors, given various numbers in the raceway. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions: Use the *National Electrical Code*, Table 310-16 and Note 8 following the tables to calculate ampacity of conductors, given various numbers in a raceway. Complete the chart below using the values given for copper wire, type THW.

THW#	Number In Raceway	Ampacity	Number In Raceway	Ampacity
8	3	A. __________	6	G. __________
10	3	B. __________	27	H. __________
4	3	C. __________	9	I. __________
00	3	D. __________	8	J. __________
250 MCM	3	E. __________	8	K. __________
3	3	F. __________	17	L. __________

CONDUCTORS
UNIT XII

ASSIGNMENT SHEET #3 — CALCULATE AMPACITY AND CONDUCTOR SIZES FOR SPECIFIC TYPES OF LOADS

NAME ________________________________ SCORE ______________

The electrical worker must be able to calculate correct ampacity and conductor size for various types of loads. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions: Use the *National Electrical Code*, Article 424-3(a) and (b), Article 430-22 and Tables 310-16 and 430-22(a) to calculate ampacities and conductor sizes for specific types of loads.

PART I

Full-Load Amperes	Fixed Electric Space Heater Amperes	Conductor Size at 85°C
A. 27	______________	______________
B. 65	______________	______________
C. 72	______________	______________

PART II

Single Motor Load Amperes	Type of Motor	Full-Load Motor Amperes	Conductor Size at 85°C
A. 43	Elevator motor, continuous rated	______________	______________
B. 90	Varying duty, 30-60 minute rated	______________	______________
C. 110	Pump motor, 5 minute rated	______________	______________
D. 86	Valve motor, 15 minute rated	______________	______________
E. 17	Metal roll, 30-60 minute rated	______________	______________

CONDUCTORS
UNIT XII

ASSIGNMENT SHEET #4 — SELECT CORDS FOR VARIOUS APPLICATIONS

NAME ______________________________ SCORE ______________

The electrical worker must be able to select cords based on ampacity and usage conditions.

Directions: Using Tables 400-4 and 400-5 in the NEC, select the proper cord type letter and conductor size for various conditions.

(NOTE: Type letter blanks may have more than one answer.)

Machine	Type	Size
A. Machine shop where cutting oil is used, load 28 amps		
B. Computer room, load 16 amps		
C. Commercial kitchen, load 54 amps		
D. Elevator lighting, load 15 amps		

CONDUCTORS
UNIT XII

ASSIGNMENT SHEET #5 — SELECT PROPER TYPES OF INSULATION

NAME ______________________________ SCORE ______________

The industrial electrician must be able to select insulation according to its intended use.

PART I

Directions: Using Table 310-13 in the *National Electrical Code*, select proper insulation types for each of the following situations. Type letter blanks may have more than one answer.

A. Boiler room where there is high humidity and high heat

____

B. Machine shop where there is cutting oil in use

____

C. Computer room with normal heat and humidity

____

D. Car wash with normal temperatures and high humidity

____

E. Commercial kitchen with high temperature and normal humidity

____

ASSIGNMENT SHEET #5

PART II

Use the *National Electrical Code*, Table 310-13 to find temperature rating in degrees centigrade and degrees Fahrenheit for each of the following insulation types, under normal uses.

	Type	°C	°F
A.	T	____________	____________
B.	TW	____________	____________
C.	THW	____________	____________
D.	THHN	____________	____________
E.	MTW (wet location)	____________	____________
F.	RHH	____________	____________
G.	THWN	____________	____________
H.	A	____________	____________
I.	ZW (dry location)	____________	____________
J.	AVL	____________	____________
K.	SA	____________	____________
L.	MI	____________	____________
M.	USE	____________	____________
N.	PFA	____________	____________
O.	RUW	____________	____________

CONDUCTORS
UNIT XII

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. #12 AWG
B. #8 AWG
C. #10 AWG
D. #3 AWG
E. #2 AWG
F. #250 MCM
G. #500 MCM
H. #1750 MCM
I. #4 AWG
J. #4 AWG
K. #000 AWG

Assignment Sheet #2

A. 50 amperes
B. 30 amperes
C. 85 amperes
D. 175 amperes
E. 255 amperes
F. 100 amperes
G. 40 amperes
H. 18 amperes
I. 59.5 amperes
J. 122.5 amperes
K. 178.5 amperes
L. 70 amperes

Assignment Sheet #3

PART I

A. 33.75, #10 AWG
B. 81.25, #4 AWG
C. 90, #4 AWG

PART II

A. 60.2, #6 AWG
B. 135, #1 AWG
C. 93.5, #4 AWG
D. 103.2, #3 AWG
E. 16.15, #16 AWG

Assignment Sheet #4

	Type	Size
A.	SJEO, SJO, SJOO, SJTO	#8 AWG
B.	DP	#12 AWG
C.	SE, SEO, SJ	#4 AWG
D.	E, EN, EO	#12 AWG

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #5

PART I

A. MTW, THW, THWN
B. MTW
C. T, TW, THHN, THW, THWN
D. TW, MTW, THW, THWN
E. THHN, MTW, THW, THWN

PART II

A. 60°C, 140°F
B. 60°C, 140°F
C. 75°C, 167°F
D. 90°C, 194°F
E. 60°C, 140°F
F. 90°C, 194°F
G. 75°C, 167°F
H. 200°C, 392°F
I. 90°C, 194°F
J. 110°C, 230°F
K. 90°C, 194°F
L. 85°C, 185°F
M. 75°C, 167°F
N. 90°C, 194°F
O. 60°C, 140°F

CONDUCTORS
UNIT XII

JOB SHEET #1 — INSTALL CORD ON UTILIZATION EQUIPMENT

A. Equipment and materials needed

1. Pouch tools
2. Cord connector
3. Wire nuts
4. Appropriate appliance cord

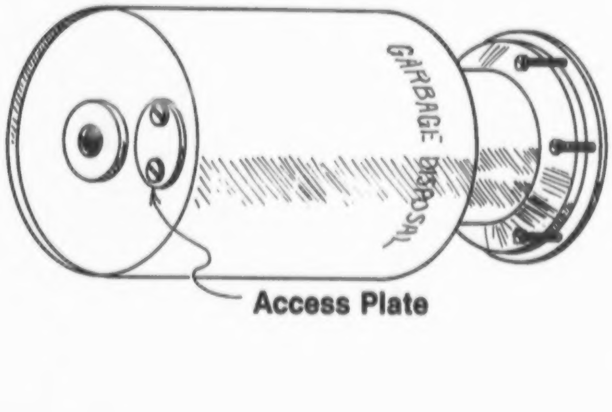
   (NOTE: Cord must be acceptable to the NEC and local code enforcing agent.)
5. Small fixed appliance
6. Safety glasses

B. Procedure

1. Gather tools and equipment and put on safety glasses.
2. Locate appliance manufacturer's specification plate.
3. Compare appliance specifications to cord selected.

   (NOTE: Be sure the cord will reach the outlet you plan on using.)
4. Remove access plate from appliance. (Figure 1)

FIGURE 1



JOB SHEET #1

5. Install cord connector.

6. Connect cord conductors to appropriate appliance terminals or conductors.

7. Adjust cord inside unit.

   (NOTE: Make sure all conductors are free moving and not cramped.)

8. Tighten cord connector.

9. Replace access plate.

   (NOTE: If an equipment grounding terminal is not provided inside the unit termination space, you can add a grounding terminal.)

10. Plug unit into appropriate receptacle.

    (NOTE: Be sure and plug it into the switched receptacle.)

11. Test appliance for correct operation.

    (NOTE: You should have water running into the disposal as you test it.)

12. Clean work area; put away all equipment and materials.

CONDUCTORS
UNIT XII

JOB SHEET #2 — USE A FISH TAPE TO INSTALL WIRE IN CONDUIT

A. Equipment and materials needed

1. 60 feet of conduit
2. Steel fish tape, 100 or 200 feet long
3. 500 feet of #10 THHN wire
4. Pouch tools
5. Wire-pulling compound

B. Procedure

(NOTE: Work in teams of three or more.)

1. Cut six 70-foot pieces of #10 THHN.

2. Lay out wire at feed-in end of conduit run, straight enough to be installed without kinking or becoming tangled.

3. Push fish tape into opposite end of conduit run.

   (NOTE: If it is difficult to push the tape around the last 90-degree bend, grip the fish tape with lineman's pliers about 1 or 2 inches from the end and push; or while pushing on fish tape, have someone tap on conduit near the 90-degree bend where the difficulty seems to be.)

4. Skin back about 5 inches of insulation on each wire at fish-tape-connection end.

5. Attach wires to fish-tape eye.

   (NOTE: Squeeze bent wires, making joint the smallest size practical, and tape. Apply tape tightly from conductor toward fish tape. Taping tightly leaves the tape with no leading edges to make pulling more difficult.)

6. Lubricate the connection.

7. Pull fish tape very slowly at first to get the connection into the conduit.

   (NOTE: The feed-in person can help by pushing slightly on conductors. When pulling fish tape, exert a smooth steady pull; do not jerk.)

JOB SHEET #2

8. Pull until conductor is through conduit at appropriate length.

   (NOTE: Have instructor evaluate your work.)

9. Clean work area; put away all equipment and materials.

CONDUCTORS
UNIT XII

JOB SHEET #3 — PREPARE AN ALUMINUM CONDUCTOR FOR TERMINATION

A. Equipment and materials needed

1. Pouch tools
2. Electricians knife
3. Wire brush
4. Antioxidant (oxiban or equivalent)
5. #2 single lug terminal cu/al

B. Procedure

1. Remove ¾ inch of insulation from conductor with knife.

   (NOTE: Do not circle the conductor with the knife. This usually nicks the wire strands and reduces their strength and conducting capacity.)

2. Remove any oxide coating with wire brush.

   (NOTE: Oxide coating is a dark, dull coating. It is important to remove it because aluminum oxidizes rapidly.)

3. Apply antioxidant to conductor.

4. Insert the conductor in the lug and tighten per manufacturer's torque specifications.

5. Allow several minutes to elapse then retighten.

   (NOTE: The strands will settle into place making a second tightening necessary.)

CONDUCTORS
UNIT XII

PRACTICAL TEST
JOB SHEET #1 — INSTALL CORD ON UTILIZATION EQUIPMENT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Chose proper cord.	______	______
3. Installed cord connector properly.	______	______
4. Installed cord properly.	______	______
5. Connection mechanically and electrically secure.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Good conductor terminations	4	3	2	1
Chose proper cord	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

CONDUCTORS
UNIT XII

PRACTICAL TEST
JOB SHEET #2 — USE A FISH TAPE TO INSTALL WIRE IN A CONDUIT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cut wire proper length.	______	______
3. Layed out wire correctly.	______	______
4. Attached wire to fish tape properly.	______	______
5. Pulled wire correctly.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Layed out wire correctly	4	3	2	1
Performed pull correctly	4	3	2	1
Insulation not damaged	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

CONDUCTORS
UNIT XII

PRACTICAL TEST
JOB SHEET #3 — PREPARE AN ALUMINUM CONDUCTOR FOR TERMINATION

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Stripped conductor properly.	______	______
3. Removed oxide coating.	______	______
4. Applied antioxidant.	______	______
5. Tightened lug.	______	______
6. Retightened lug.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Properly stripped	4	3	2	1
Properly tightened lug	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

CONDUCTORS
UNIT XII

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

_____a. Conductor made of aluminum

_____b. The diameter of a conductor in thousandths of inches multiplied times itself

_____c. Assigning colors to conductors based on their uses

_____d. A conductor having no covering or electrical insulation

_____e. Two or more conductors grouped together in an overall covering

_____f. Two or more stranded conductors grouped together in a flexible covering

_____g. Conductor made of copper

_____h. The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

_____i. American Wire Gauge

_____j. Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

_____k. Conductor encased within material of composition and thickness not recognized by the NEC as electrical insulation

_____l. Identification accepted by the trade in referring to the particular types of insulation

_____m. One thousandth of an inch

_____n. Conductor encased within material of composition and thickness recognized by the NEC as electrical insulation

1. Aluminum wire
2. Ampacity
3. AWG
4. Base conductor
5. Cable
6. Circular mils
7. Color coding
8. Copper-clad aluminum
9. Copper wire
10. Cord
11. Covered
12. Fish tape
13. Grounded conductor
14. Insulated
15. Mil
16. Type letter
17. Grounding conductor

TEST

_____o. Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

_____p. Connects equipment or wiring circuit grounded conductor to a grounding electrode

_____q. A circuit conductor that is intentionally connected to the earth or some conductor that serves in place of the earth

2. List six factors that determine type and size of conductors.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

3. Select from the following list characteristics of good connections by placing an "X" in the blanks preceding the correct characteristics.

_____a. Use approved devices and oxidation inhibitors when connecting copper to aluminum

_____b. Provide full contact

_____c. Are made with magnetic screwdriver

_____d. Are tight

_____e. Require no tools for installation

_____f. Are clean

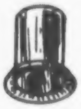
_____g. Provide quick disconnect

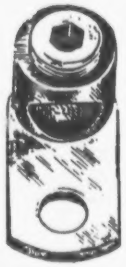
_____h. Show bright terminal connection

_____i. Are strong

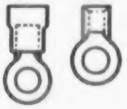
TEST

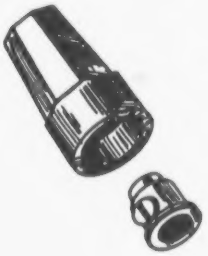
4. Identify the following types of connectors, terminals, and lugs. Write the correct names in the blanks.



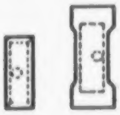


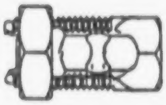
a. ______________________________ b. ______________________________





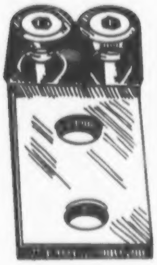
c. ______________________________ d. ______________________________

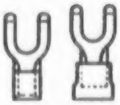




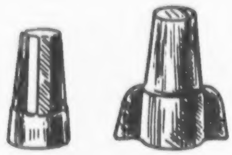
e. ______________________________ f. ______________________________

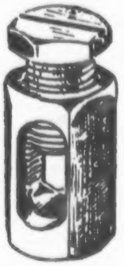
TEST



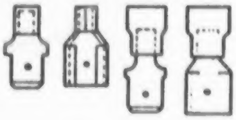


g. ______________________________ h. ______________________________





i. ______________________________ j. ______________________________



k. ______________________________

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TEST

5. Complete the following chart concerning types of insulation by inserting the correct insulation names.

Insulation Name	Code Letters	Application	Characteristics
a.	T	Dry locations	Flame retardant
b.	TW	Dry and wet locations	Flame retardant, moisture resistant
c.	THHN	Dry locations	Flame retardant, heat resistant
d.	MTW	Machine tool wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670) Machine tool wiring in dry locations as permitted in NFPA Standard No. 79 (See Article 670)	Flame retardant, moisture, heat, and oil resistant
e.	THW	Dry and wet locations Special applications within electric discharge lighting equipment; limited to 1,000 open-circuit volts or less (size 14-8 only as permitted in Section 410-31)	Flame retardant, moisture and heat resistant
f.	THWN	Dry and wet locations	Flame retardant, moisture and heat resistant

TEST

6. List three conductors commonly found in electrical wiring.

a. ____

b. ____

c. ____

7. Match types of cables found in the electrical field on the right with their correct uses.

_____a. Dry and wet locations; suitable for burial

_____b. Dry locations; used in majority of residential interior wiring

_____c. Used for power, lighting, control, signal, and communication circuits

_____d. Dry and wet locations; used for services, feeders, and branch circuits

_____e. Dry locations; used for branch circuits and feeders in both exposed and concealed work

_____f. Dry and wet lcoations; used for service entrance conductors where applicable

1. NM (NMB)
2. UF
3. SE
4. AC
5. MI
6. TC

8. Select true statements concerning cords and their conductors by placing an "X" in the blanks preceding the true statements.

_____a. Cords used in a grounded system must have an identified grounded conductor.

_____b. Cords which have a conductor with red or red with yellow striped insulation shall use that conductor for grounding only.

_____c. Ungrounded conductors can be any color that is designated for grounded or grounding conductors.

_____d. Cords should be used within their amp and insulation rating or classification.

TEST

9. Complete the following statements concerning cables and their conductors by inserting the words that best complete each statement.

   a. When used in a grounded system an ________________ grounded conductor (white or natural gray) must be in the cable.

   b. A bare or ________________ conductor is always used as the equipment grounding conductor.

   c. ________________ conductors can be any color other than those designated for grounded or grounding conductors.

   d. Cables should be used within their ________________ and ________________ rating.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

10. Select conductors for various ampacities and temperatures. (Assignment Sheet #1)

11. Calculate ampacity of conductors, given number of conductors in raceway. (Assignment Sheet #2)

12. Calculate ampacity and conductor sizes for specific types of loads. (Assignment Sheet #3)

13. Select cords for various applications. (Assignment Sheet #4)

14. Select proper types of insulation. (Assignment Sheet #5)

15. Demonstrate the ability to:

    a. Install cord on utilization equipment. (Job Sheet #1)

    b. Use a fish tape to install wire in conduit. (Job Sheet #2)

    c. Prepare an aluminum conductor for termination. (Job Sheet #3)

CONDUCTORS
UNIT XII

ANSWERS TO TEST

1.	a.	1	f.	10	k.	11	p.	17
	b.	6	g.	9	l.	16	q.	13
	c.	7	h.	2	m.	15		
	d.	4	i.	3	n.	14		
	e.	5	j.	8	o.	12		

2. a. Full load amperes
   b. Number of conductors
   c. Type of load served
   d. Length of run
   e. Ambient temperature
   f. Voltage

3. a, b, d, f, i

4. a. Crimp sleeve connector
   b. Single terminal
   c. Set screw lug
   d. Ring lugs
   e. Crimp-type butt connectors
   f. Split bolt lug
   g. Twin or double terminal
   h. Spade connectors
   i. Wire nut lugs
   j. Service entrance lug
   k. Quick disconnect connector

5. a. Thermoplastic
   b. Moisture-resistant thermoplastic
   c. Heat-resistant thermoplastic
   d. Moisture-, heat-, and oil-resistant thermoplastic
   e. Moisture- and heat-resistant thermoplastic
   f. Moisture- and heat-resistant thermoplastic

6. a. Copper
   b. Aluminum
   c. Copper-clad aluminum

ANSWERS TO TEST

7. a. 2
   b. 1
   c. 6
   d. 5
   e. 4
   f. 3

8. a, d

9. a. Identified
   b. Green
   c. Ungrounded
   d. Amp, condition

10.-14. Evaluated to the satisfaction of the instructor

15. Performance skills evaluated to the satisfaction of the instructor

LOW VOLTAGE WIRING
UNIT XIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to install low voltage wiring systems in a residence. Competencies will be demonstrated by completing the assignment sheet, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to low voltage wiring circuits with their correct definitions.
2. Identify the parts of a low voltage wiring system.
3. Describe the process that takes place during a low voltage lighting circuit off/on cycle.
4. Describe the process that takes place during the energizing of a chime circuit.
5. Complete the thermostat drawing of the manual fan switching circuit to indicate the path of current flow through the fan control switch and fan relay.
6. Complete the thermostat drawing to indicate the path of current flow with the thermostat system switch in the cool position and the fan switch on auto.
7. Complete the thermostat drawing to indicate the parts of current flow with the thermostat system switch in the heat position and the fan switch on auto.
8. Complete statements concerning anticipation circuits on low voltage thermostats.
9. Match communication circuits with their correct characteristics.

OBJECTIVE SHEET

10. Complete statements concerning smoke and fire alarm systems.

11. Select true statements concerning the operation of a garage door opener.

12. Draw a wiring diagram indicating the proper connection for bell circuit equipment. (Assignment Sheet #1)

13. Demonstrate the ability to:

    a. Wire a two switch low voltage lighting circuit. (Job Sheet #1)

    b. Wire a two button chime circuit. (Job Sheet #2)

    c. Determine heat anticipator current draw. (Job Sheet #3)

    d. Install a wall thermostat. (Job Sheet #4)

LOW VOLTAGE WIRING
UNIT XIII

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheet.

F. Discuss information and assignment sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Contact a local sales distributor to visit class and demonstrate low voltage lighting and signaling devices.
2. Discuss advantages and disadvantages of low voltage lighting.
3. Contact a local telephone company representative to visit class and demonstrate phone systems. Discuss local requirements for installation of equipment and system.
4. Contact local C.A.T.V. (Community Antenna Television) cable system to visit class and discuss local requirements for installation of equipment and connection to their system.
5. Plan an outside field trip to local phone company and C.A.T.V. cable system switching locations.
6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. Foley, Joseph H. *Electrical Wiring Fundamentals*. New York: Gregg, McGraw-Hill Book Company, 1981.

B. Holzman, Harvey N. *Modern Residential Wiring*. South Holland, IL: Goodheart-Wilcox Company, Inc., 1986.

C. Mullin, Ray C. *Electrical Wiring: Residential*. Eighth Edition. Albany, NY: Delmar Publishers, Inc., 1984.

D. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

SUGGESTED SUPPLEMENTAL MATERIAL

Text — Kubala, Thomas S. *Electricity 1: Devices, Circuits, and Materials*. Fourth Edition. Albany, NY: Delmar Publishers, Inc., 1986.

(NOTE: To order this text, write to 2 Computer Drive West, Box 15-015, Albany, NY 12212.)

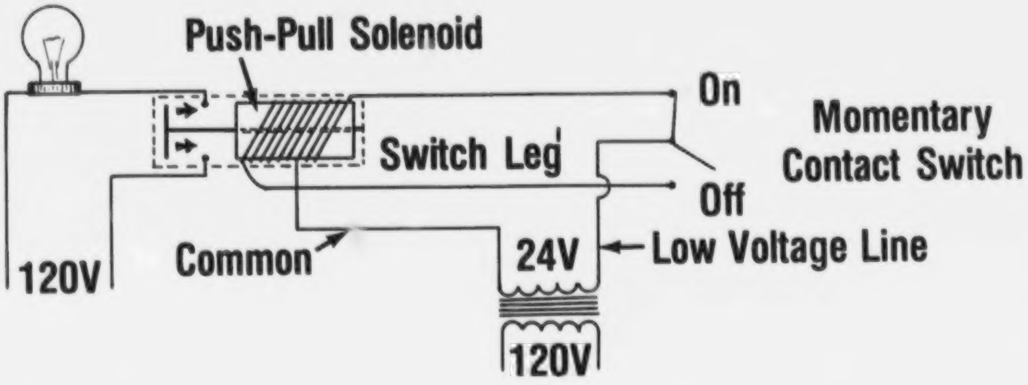
Catalog — Hunzicker Brothers Catalog, 501 N. Virginia, Oklahoma City, OK 73125.

Filmstrip — *Electrical House Wiring Explained #804*. Bergwall Productions, Inc., 839 Stewart Ave., Garden City, NY 11530.

(NOTE: This filmstrip covers installation for signal systems, telephone, television, and smoke and fire detectors.)

672

Low Voltage Off/On Switching Cycle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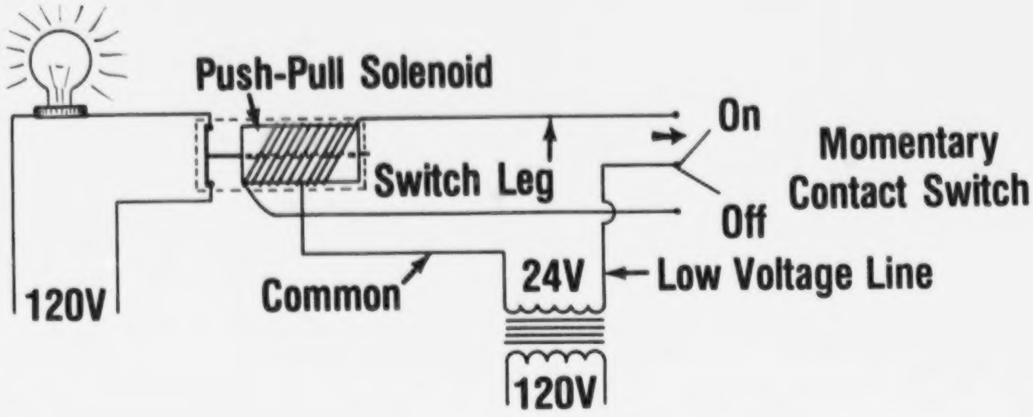
Momentary Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V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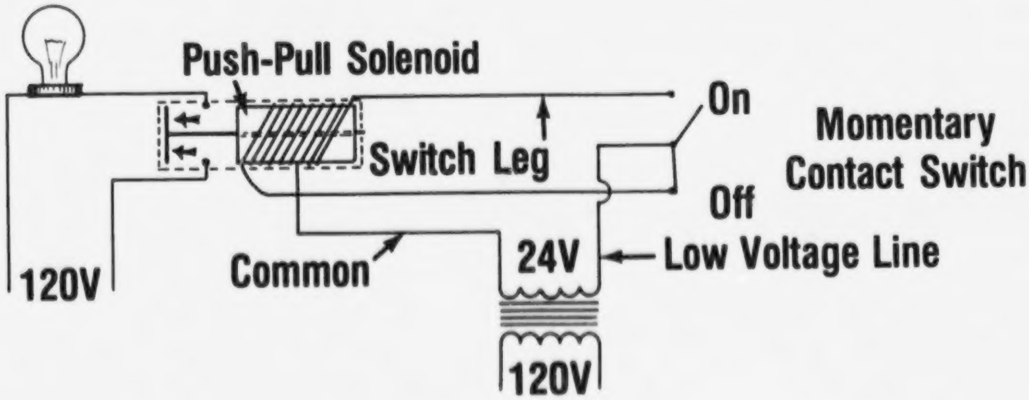
Momentary Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V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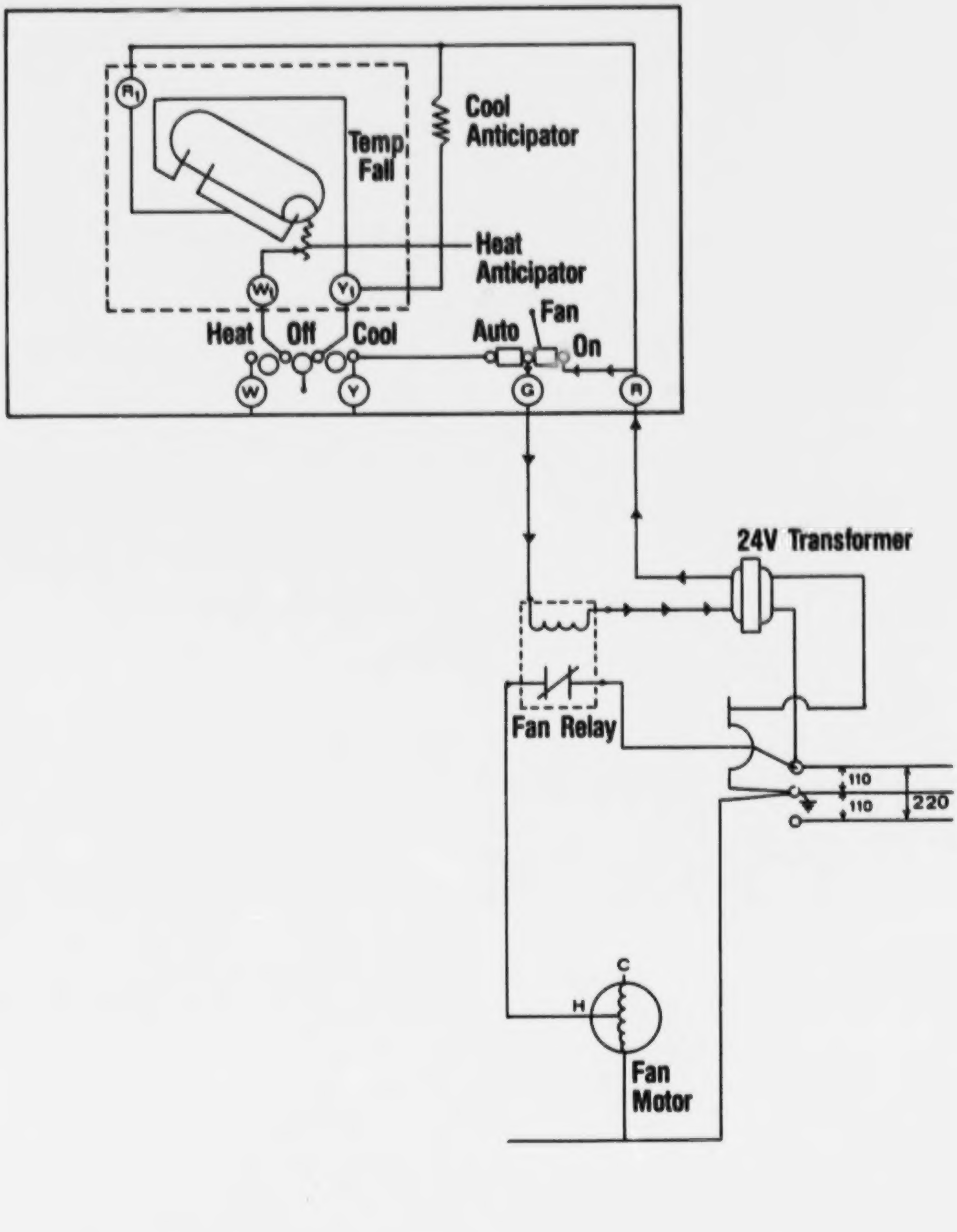
On
Momentary Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

Thermostat — Manual Fan Control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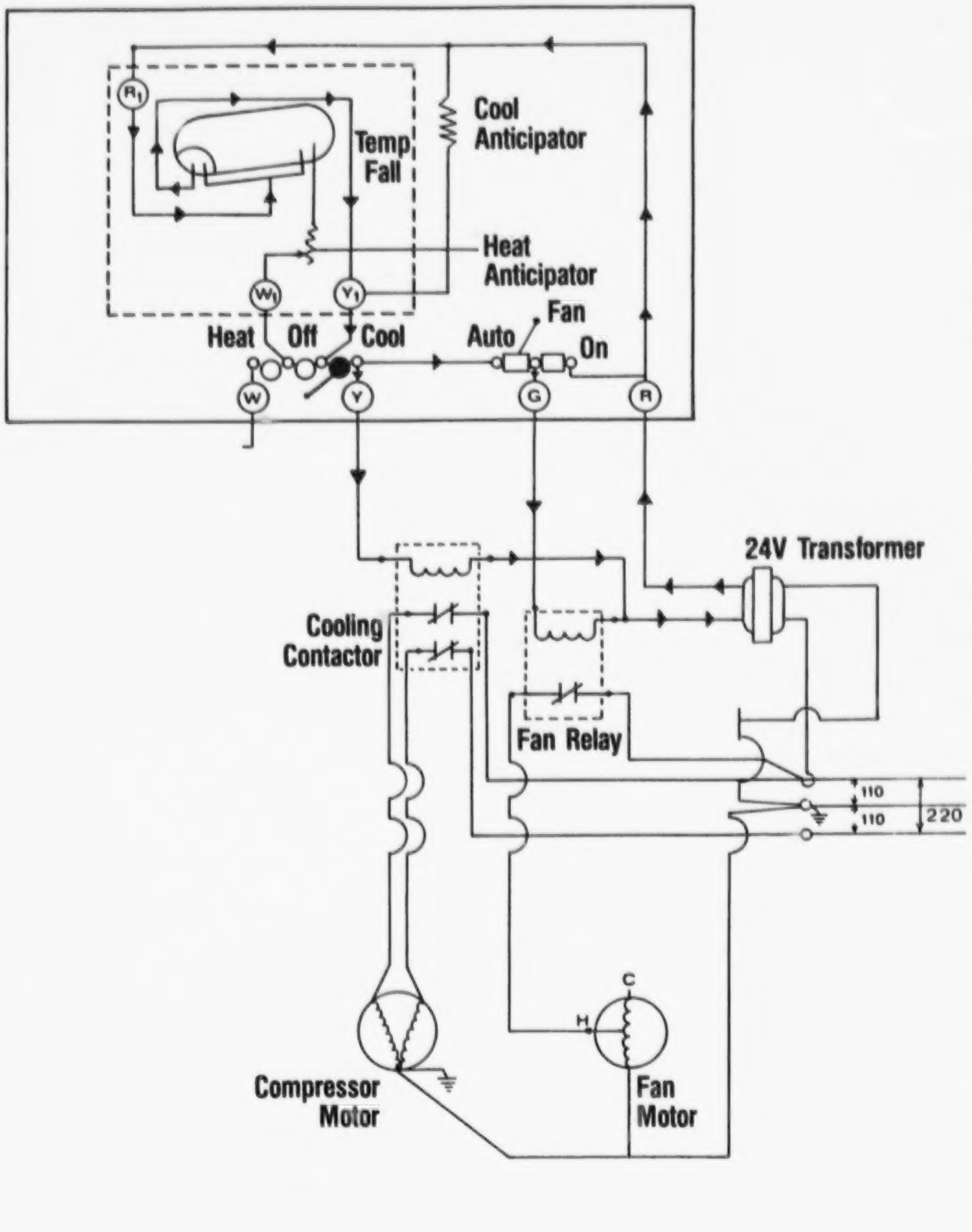
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

BW-741

Thermostat — Cooling Circuit With Automatic Fan Control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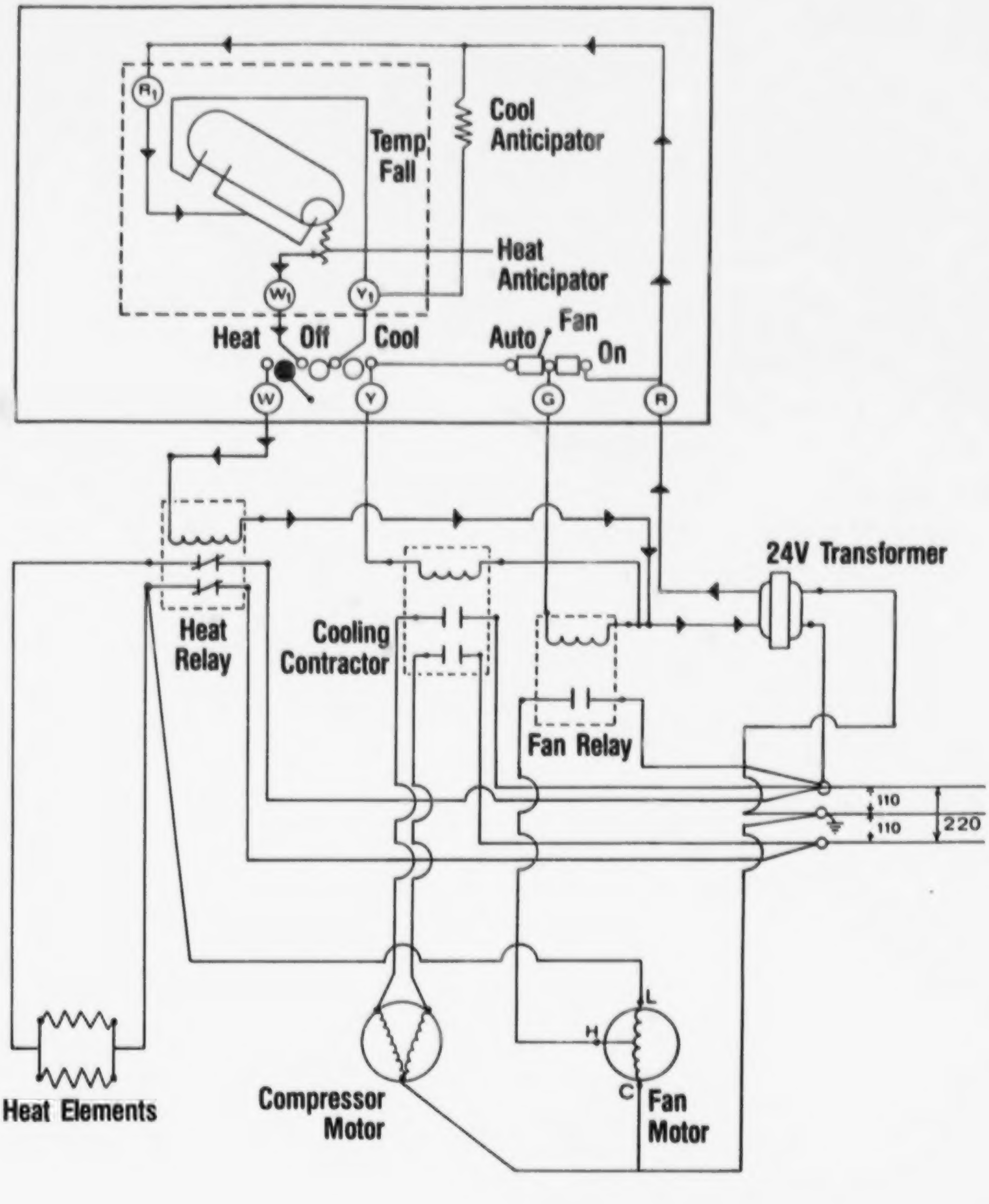
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

TM 3
Objective VI

Thermostat — Heating Circuit With Automatic Fan Control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Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

LOW VOLTAGE WIRING
UNIT XIII

INFORMATION SHEET

I. **Terms and definitions**

A. Coaxial cable — Conductor used for carrying communication signals

B. Heat detectors — A fire warning device commonly used in a residence; available in two types: fixed or rate-of-rise temperature detectors

C. Momentary contact switch — A switch that is closed or opened only while the operator touches it

D. Pull-push solenoid — Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has current applied to it

E. Relay — Electromagnetic device for remote or automatic control

F. Smoke detector — A fire warning device commonly used in a residence that is available in two types: photoelectric or ionization

G. Solenoid — Electromagnetic cylinder that will move an iron plunger when current is applied

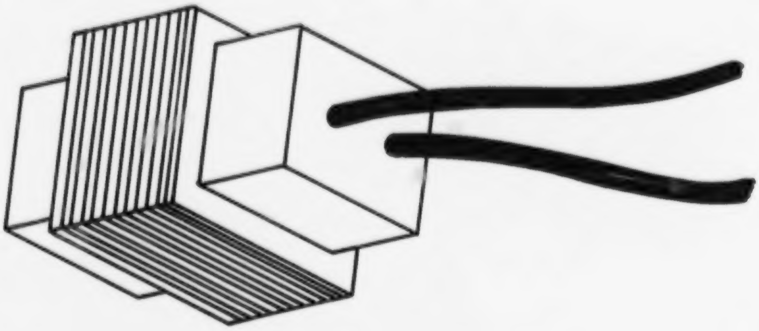
H. Telephone system — A personal communication system installed in the home to provide outside conversation with the world

I. Thermostat — A device that senses temperature variations from a set point and, in turn, acts to control a circuit

J. Transformer — An electrical device used to step up or step down a primary voltage to a desired secondary voltage

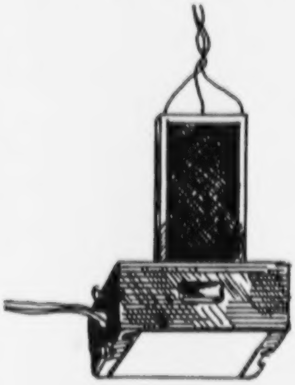
II. **Parts of a low voltage wiring system**

A. 24 volt transformer

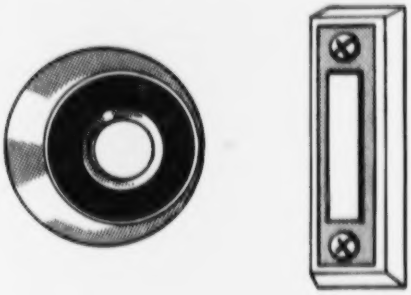


INFORMATION SHEET

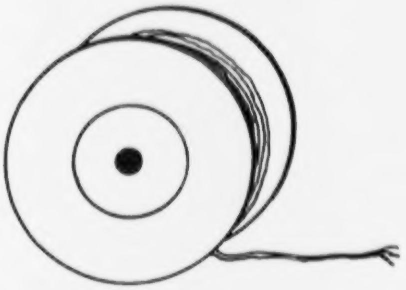
B. Low voltage lighting relay



C. Momentary contact switch



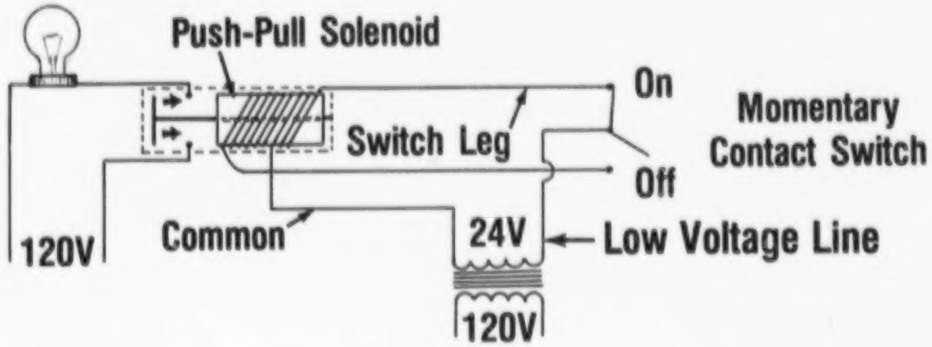
D. Low voltage cable



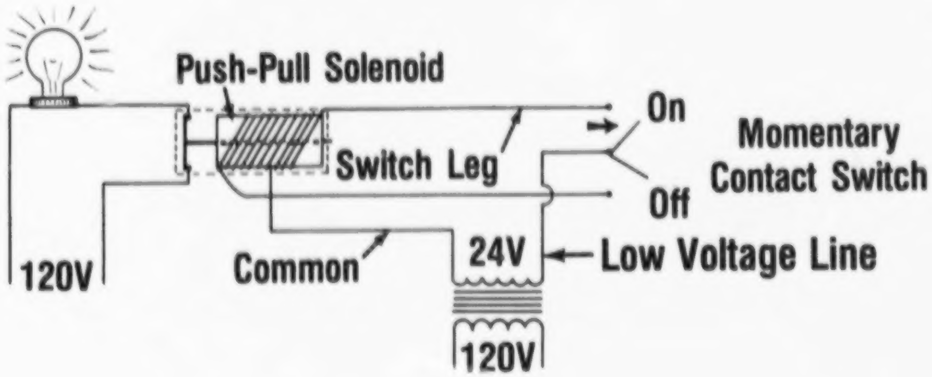
INFORMATION SHEET

III. **Low voltage lighting circuit off/on cycle**

A. "On" switch is pushed


Push-Pull Solenoid
On
Momentary Contact Switch
Switch Leg
Off
Common
120V
24V
Low Voltage Line
120V

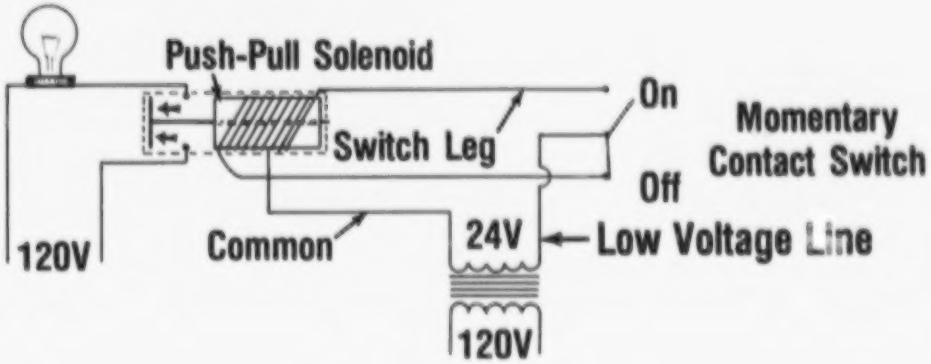
1. Circuit is completed to closing movement of solenoid in relay
2. Core is moved and circuit is completed


Push-Pull Solenoid
On
Momentary Contact Switch
Switch Leg
Off
Common
120V
24V
Low Voltage Line
120V

INFORMATION SHEET

B. "Off" switch is pushed

1. Circuit is completed to opening movement of solenoid in relay
2. Core is moved and circuit is opened


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

IV. **Process that takes place during the energizing of a chime circuit**

(NOTE: This is a front door signal on a two note chime.)

A. Button is pushed

1. Circuit is completed to solenoid
2. Plunger is drawn down to chime and sound is made

B. Button is released

1. Circuit is open
2. Spring pulls plunger up to upper chime and another sound is made

INFORMATION SHEET

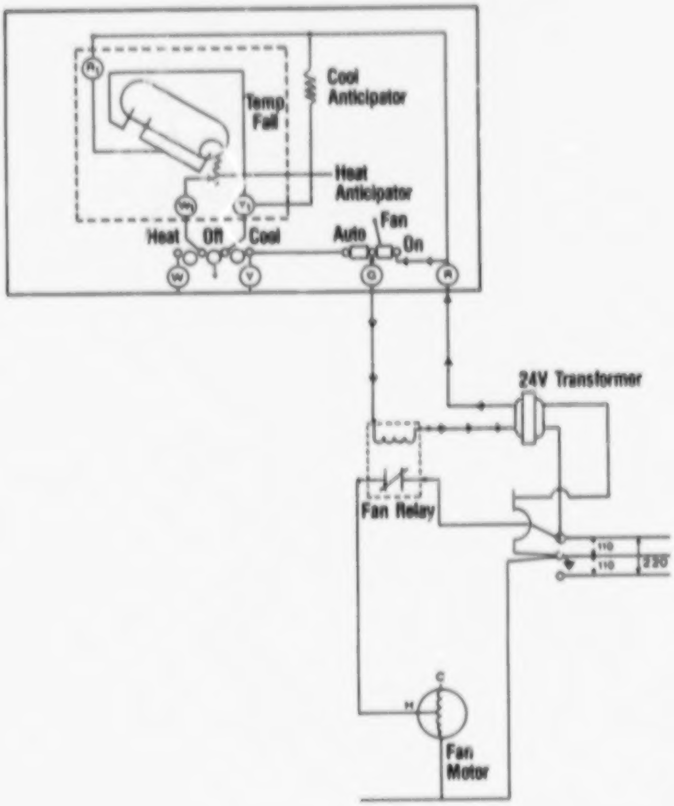
V. **Manual fan switching circuit**

A. Current from transformer goes to fan control switch

B. Closed switch directs current to fan relay control coil

(NOTE: This closes normally open contacts, and the fan motor receives line voltage and runs.)

C. Common conductor returns current to transformer


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
230
C
H
Fan Motor

INFORMATION SHEET

VI. Thermostat system switch in cool position, fan switch on auto

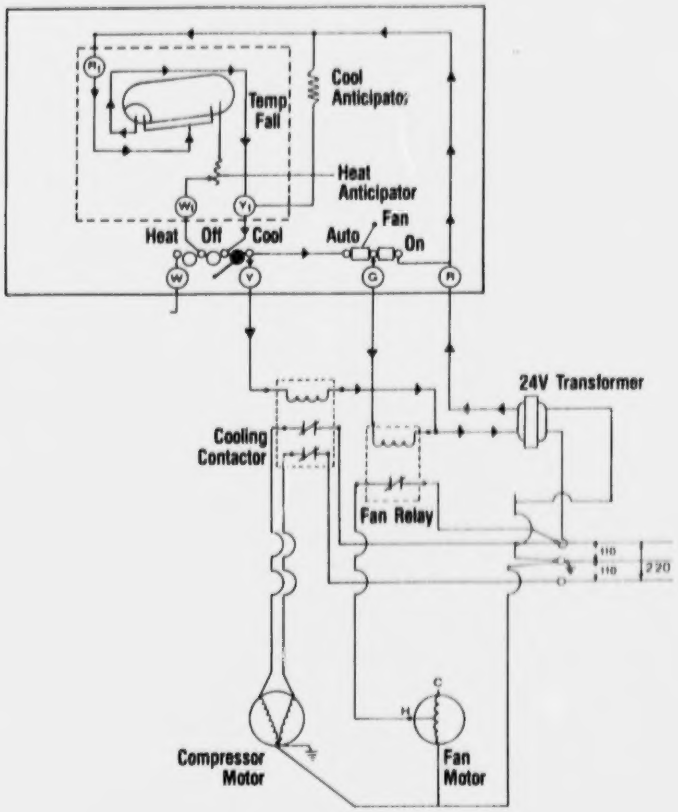
- A. Current from transformer goes to mercury bulb switch.
- B. From mercury switch current goes to the system switch.
- C. Current splits at the system switch.
  - 1. One split goes to fan switch.

    (NOTE: Follow the arrows heads, ▲.)

    - a. Through closed automatic contacts
    - b. To fan relay control coil

      (NOTE: This closes normally open relay contacts and starts fan motor.)

    - c. Back to transformer


R1
Temp. Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

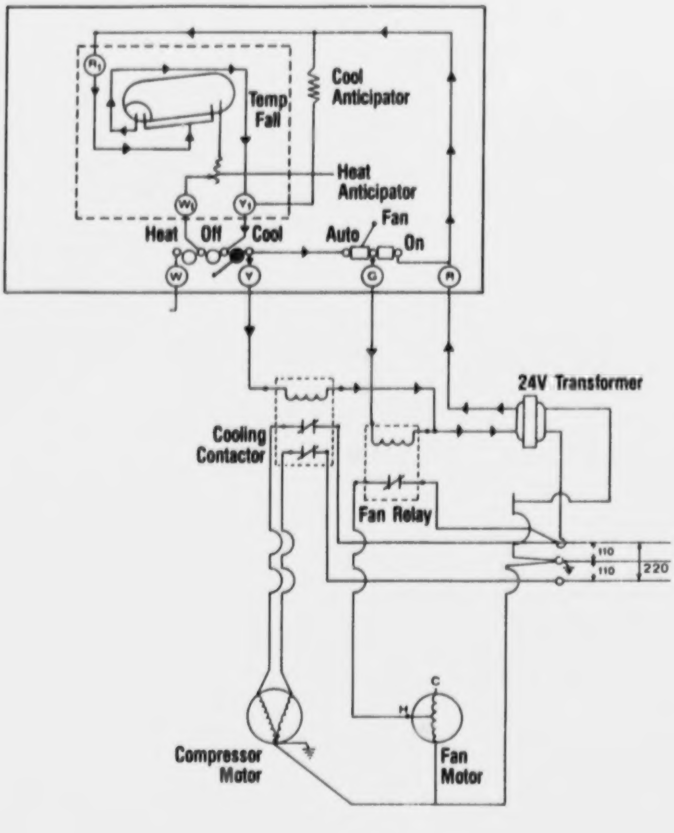
INFORMATION SHEET

2. One split goes to the cooling contactor.

   a. Through cooling contactor coil

      (NOTE: This closes normally open contacts and compressor starts.)

   b. Back to transformer


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

INFORMATION SHEET

VII. System switch in heat position

A. Current from transformer goes to mercury bulb switch

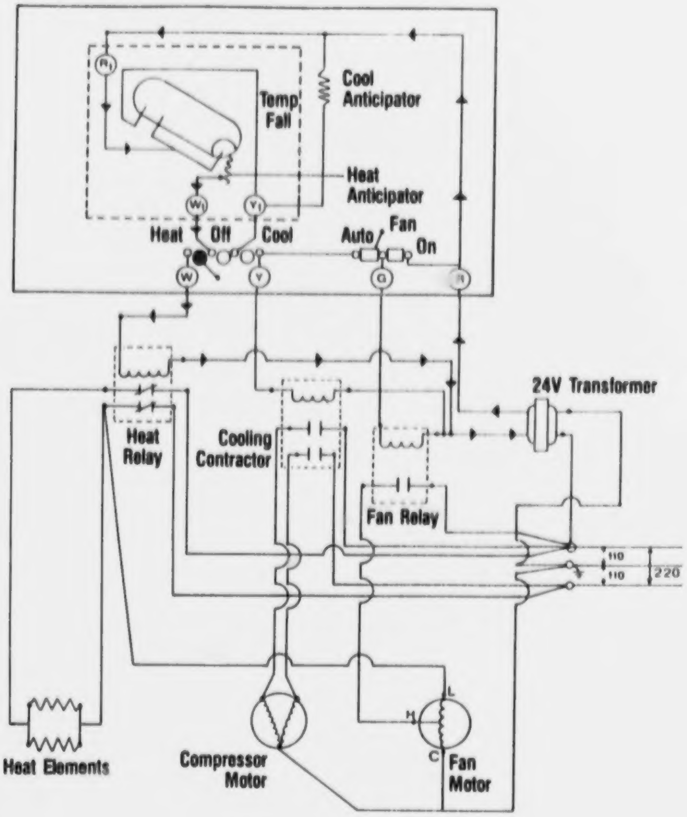
B. Through mercury bulb switch to system switch

C. Through closed contacts of heat circuit

D. To heating contactor or control valve coil

(NOTE: This closes normally open relay contacts and energizes elements and low speed fan control. On gas models a plenum switch energizes fan motor.)

E. Back to transformer


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
220
Heat Elements
Compressor Motor
L
H
C
Fan Motor

INFORMATION SHEET

VIII. Anticipator circuits on low voltage thermostats

A. Heat and cool anticipators are installed to compensate for bimetallic lag.

B. Cool anticipator

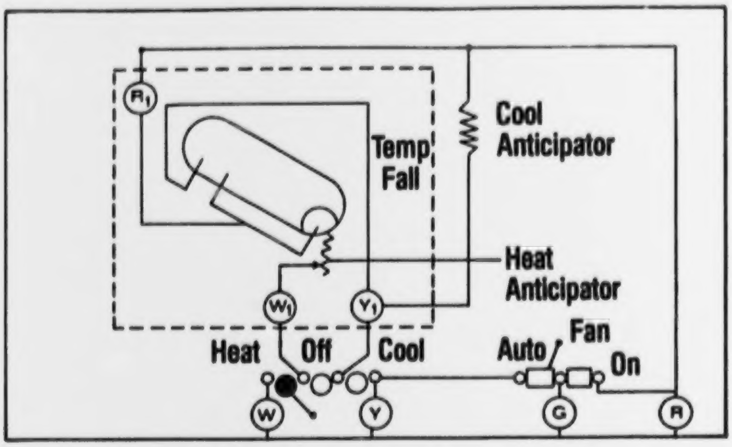
(NOTE: These are usually fixed resistors.)

1. It is wired parallel to mercury switch.
2. Current draw through the resistor causes heat.
3. Heat causes bimetal to tilt bulb and close circuit before room temperature actually reaches "on" temperature setting.

C. Heat anticipator

(NOTE: These are usually variable resistors.)

1. It is wired in series with mercury switch.
2. Current draw through switch causes heat.
3. Heat causes bimetal to tilt bulb and open circuit when temperature reaches desired room setting.


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R

INFORMATION SHEET

IX. Communication circuits and their characteristics

A. Telephone

1. The point where the local telephone's wiring ends and the home owner's interior wiring begins is called the "demarkation point".

2. The telephone wiring inside the home must comply to the rules in Article #800 of the NEC.

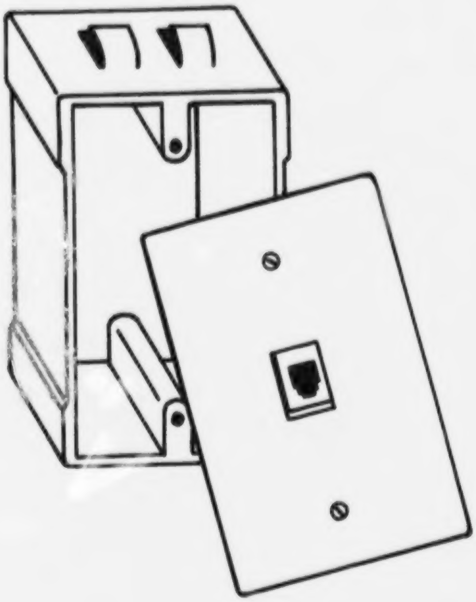
3. The most common telephone wiring for a new home or existing home extension is four conductor #22 or #24 cable.

4. The common terms for telephone cable are: 2 pair—4 conductors, 3pair—6 conductors, 12 pair—24 conductors, etc.

5. Telephone circuits require a separate pair of conductors from the telephone all the way back to the phone company's switching center.

6. For new construction installations, standard electrical boxes are used at telephone outlet locations. These boxes will support wall phones or modular plates.

   EXAMPLE:



INFORMATION SHEET

7. The two types of standard telephone wiring methods are individual cables run to each telephone outlet and a complete loop system.

   (NOTE: With loop-system should anything happen to one section of the cable, the circuit can be fed from the other direction.)

8. All telephone hook-ups are wired in a parallel pattern.

   (NOTE: NEC Art. 800 covers installation requirements for phone systems. Local telephone companys may also have additional requirements. There is little danger of electrical shock from the telephones own voltage, when the phone is not ringing (only 48 volt DC is present). The operation of the phone signaling device (ringing) requires 85 to 90 volt AC. This voltage is supplied by the telephone company. If contact is made with this higher AC voltage it can be uncomfortable but not harmful. To avoid it, take the receiver off the hook when working on the system.)

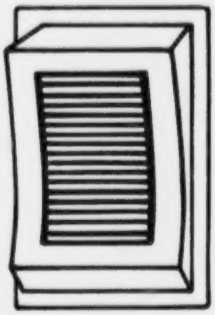
B. Intercom system

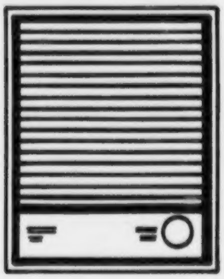
1. This is a low voltage wiring system that allows one-way monitoring or two-way conversation communications throughout the residence.

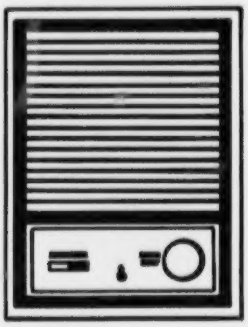
2. Most systems today also incorporate radio and tape playing through the system speakers.

3. The system also provides added security with door answering communication without opening your door to a stranger.

   (NOTE: Shown below are typical system components.)







INFORMATION SHEET

C. Television antenna

1. The television antenna and Community Antenna Television (CATV or Cable) system installed in the home is regulated by Art. #820 of the NEC.

2. Television cable is available in two basic types: twin lead (300 ohms) and coaxial (75 ohm)

3. All television cable systems must be grounded.

4. If a separate grounding electrode is used, other than service grounding electrode, the two electrodes must be bonded.

X. **Smoke and fire alarm systems**

(NOTE: NEC Article #760 pertains to requirements for fire protective systems.)

A. Fire warning devices commonly used in a residence are a heat detector and a smoke detector.

B. Heat detectors sense a specific fixed temperature, such as 135°F or 200°F, or a rate-of-rise (12 to 15 degrees per minute) such as rises caused by flash fires.

C. The two most common types of smoke detectors are:

1. Photoelectric type — This detector has a light sensor that measures the amount of light in a chamber. Smoke reduces the amount of light and an alarm is sounded.

   (NOTE: This type of detector is most useful in situations where burning materials, such as rags, mattresses, and furniture create great quantities of smoke.)

2. Ionization type — This detector has a source of particles that ionize the air in the chamber. Inside the chamber are two plates of opposite charge. The ionized air conducts a small current (millionths of an ampere) between the plates. Smoke entering this chamber restricts the current flow causing an alarm to sound.

   (NOTE: This type of detector is most useful in situations where burning materials, such as gasoline or alcohol, create very small amounts of smoke.)

D. Heat and smoke detectors installed in a residence give people early warning of the presence of fire.

(NOTE: Fire is the third leading cause of accidental fatalities. Home fires account for the biggest share of the deaths; most occur at night when people are asleep. Heat and smoke detectors are available in single or multi-installation types.)

INFORMATION SHEET

XI. Operation of a garage door opener

A. The opener contains a motor, gear reduction unit, motor reversing switch, transformer, and electric brake. All of the components are pre-assembled.

B. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers (remote control).

C. The push-button or key operated station consists of a normally-open momentary contact switch connected by 2-wire low-voltage cable to the control unit. Actuation of switches causes the step relay to close energizing the motor in the opposite direction of its previous travel.

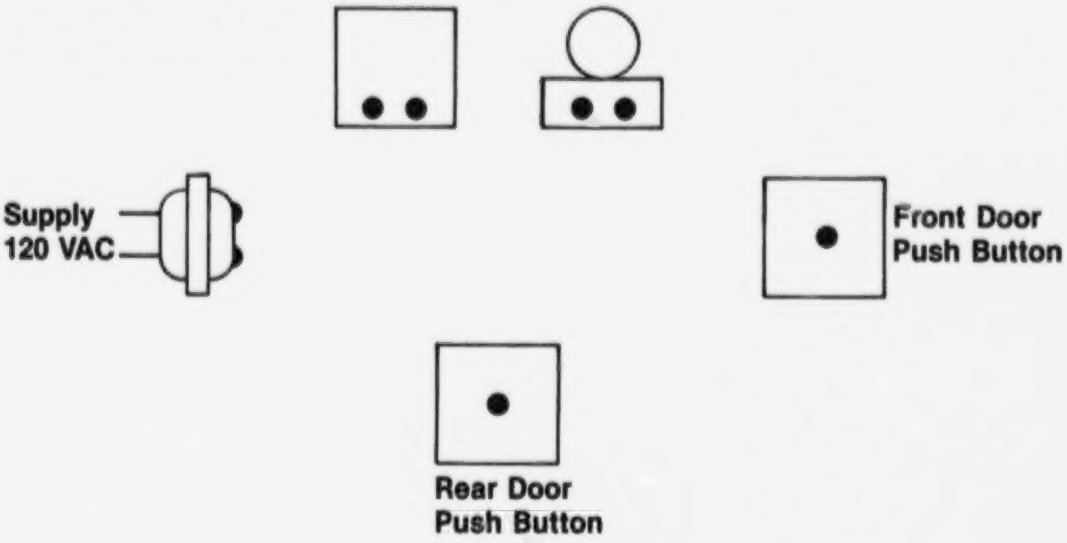
D. The radio controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency (from the remote-control device) it will energize the motor in the opposite direction of its previous travel.

LOW VOLTAGE WIRING
UNIT XIII

ASSIGNMENT SHEET #1 — DRAW A WIRING DIAGRAM INDICATING THE PROPER CONNECTION FOR BELL CIRCUIT EQUIPMENT

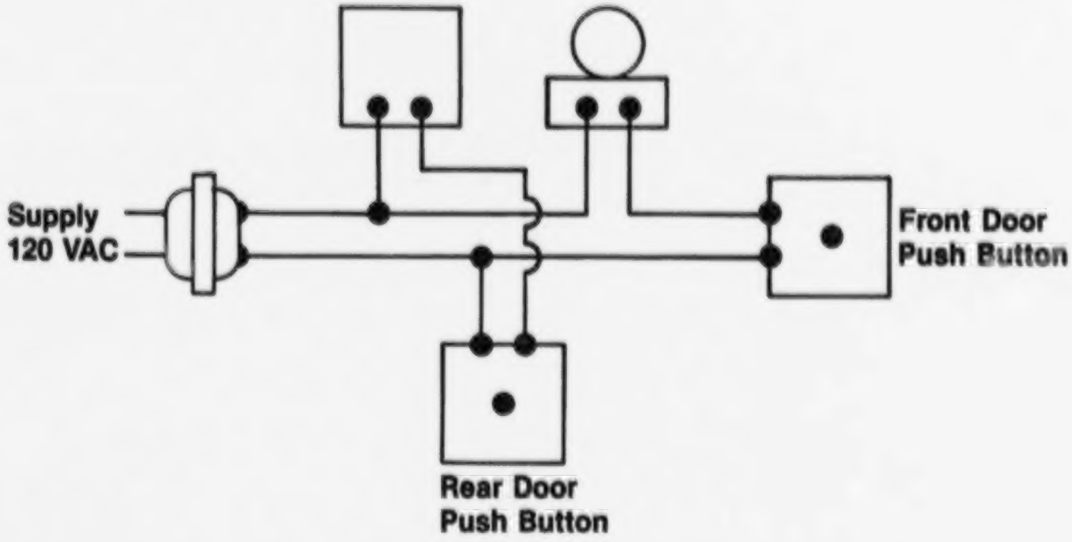
NAME ________________________ SCORE ______________

Directions: Draw a wiring diagram indicating the proper connection for the bell circuit equipment below. Make connections so that buzzer announces rear door and bell rings for front door.


Supply
120 VAC
Front Door
Push Button
Rear Door
Push Button

LOW VOLTAGE WIRING
UNIT XIII

ANSWERS TO ASSIGNMENT SHEET #1


Supply
120 VAC
Front Door
Push Button
Rear Door
Push Button

LOW VOLTAGE WIRING
UNIT XIII

JOB SHEET #1 — WIRE A TWO SWITCH LOW VOLTAGE LIGHTING CIRCUIT

A. Equipment and materials needed

1. 120-24v step down transformer
2. One 24v lighting relay
3. Two low voltage lighting switches
4. One octagon box and hanger
5. Two single gang plaster rings

   (NOTE: Two regular device boxes could be used.)
6. Three-wire low voltage cable
7. 12-2G or 14-2G NM cable
8. Wire connectors
9. Light socket
10. Incandescent bulb
11. Staples
12. 120v power supply

    (NOTE: A breaker panel with one breaker is needed)
13. 2" × 4" mockup wall or shop board
14. Fasteners (nails or screws) to secure boxes and hanger bar
15. Electrician's hammer
16. Flat blade screwdriver
17. Lineman's pliers
18. Long nose pliers
19. Knife

JOB SHEET #1

20. Wire strippers

21. Drill motor and bit or brace

    (NOTE: An extension cord will be needed if a drill motor is used.)

22. ½" or larger wood bit

23. Safety glasses

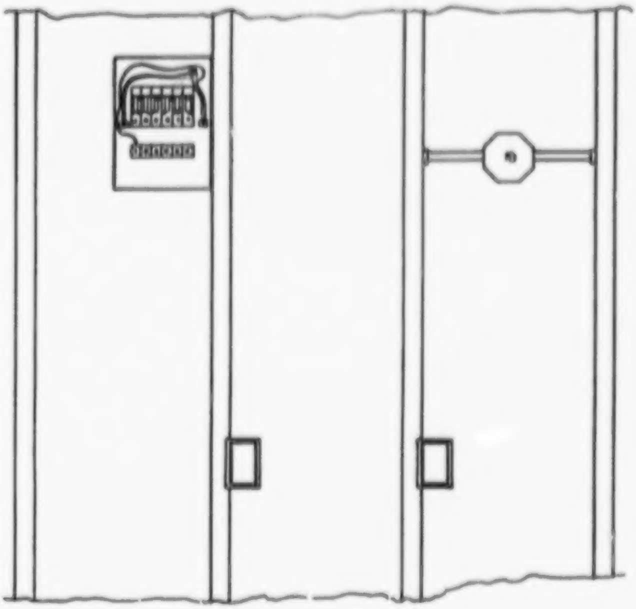
24. Portable GFI

B. Procedure

1. Put on safety glasses and gather equipment and materials.

2. Mount plaster rings, octagon box, and bar hanger. (Figure 1)

   FIGURE 1



3. Drill holes for power and low voltage cable runs.

   (NOTE: Use your GFI when drilling.)

JOB SHEET #1

4. Run 120v supply cable from panel to lighting outlet box.

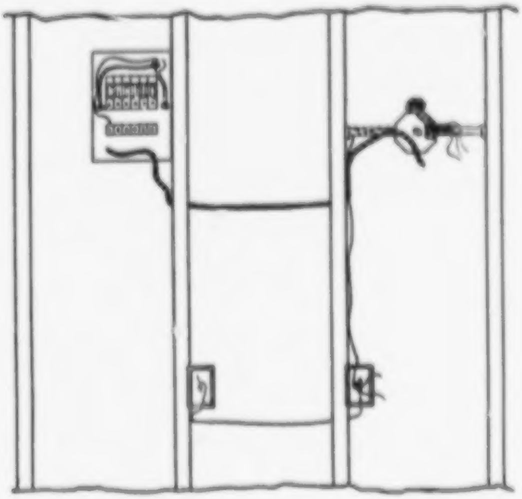
   (NOTE: In this example the transformer will be mounted at the outlet box; in a residence it must be accessible.)

5. Mount transformer on the back or top of outlet box.

6. Install lighting relay.

7. Run low voltage cable. (Figure 2)

   FIGURE 2

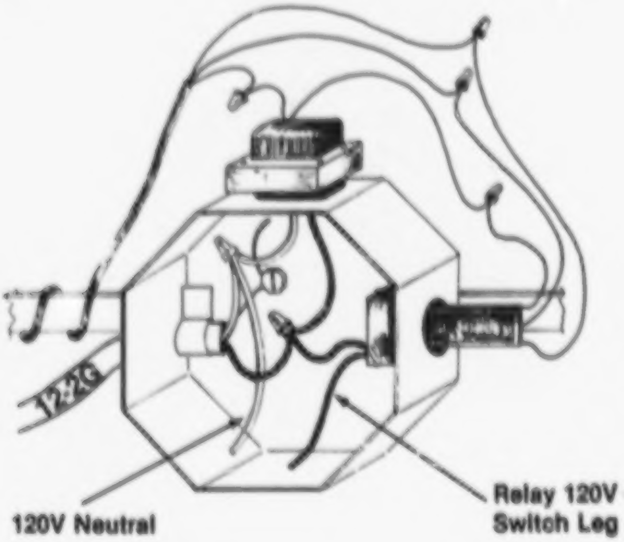


(NOTE: Wrap the cable around the bar hanger.)

JOB SHEET #1

8. Make transformer and solenoid connections. (Figure 3)

FIGURE 3



(NOTE: One transformer lead is the low voltage line, and one transformer lead goes to relay common. The remaining two relay leads should be labeled as off and on return legs for switch connections.)

9. Connect switch leg to common on both switches.

   (NOTE: A pigtail is needed on the first connection to carry the switch leg to the second switch.)

10. Connect on and off return legs to appropriate switch terminals.

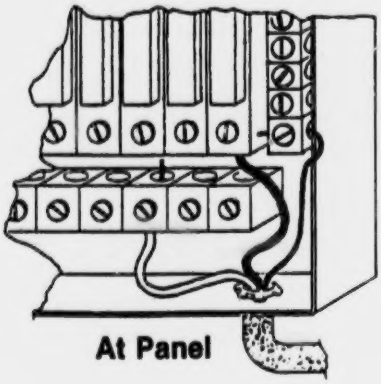
11. Mount switches.

12. Attach socket to neutral and relay 120 volt switch leg.

JOB SHEET #1

13. Make up panel. (Figure 4)

FIGURE 4



14. Turn on breaker.

15. Turn on at one switch and off at the other.

16. Turn on at other switch and off at the other.

17. Have your instructor evaluate this project.

18. Turn off breaker.

19. Clean work area and put away all equipment and materials.

LOW VOLTAGE WIRING
UNIT XIII

JOB SHEET #2 — WIRE A TWO BUTTON CHIME CIRCUIT

A. Equipment and materials needed

1. Two door bell buttons
2. 18-3 and 18-2 bell wire cable
3. 16 volt transformer
4. Chime with front and back call
5. 12 or 14-2G NM cable
6. Electrician's hammer
7. Long nose pliers
8. Flat blade screwdriver
9. Cable staples
10. 3/8" cable clamp
11. Stud wall or work board
12. 120v power supply
13. Pocket knife
14. Wire strippers
15. Wire connectors
16. Octagon box and blank plate with 1/2" K.O.
17. 3/4" #10 metal tapping screws
18. Drill motor and bit or brace
19. 1/2" or larger wood bit
20. Extension cord
21. Header board (short piece of 1" × 6" or 2" × 4")
22. Four 16 penny nails
23. Safety glasses
24. GFI

JOB SHEET #2

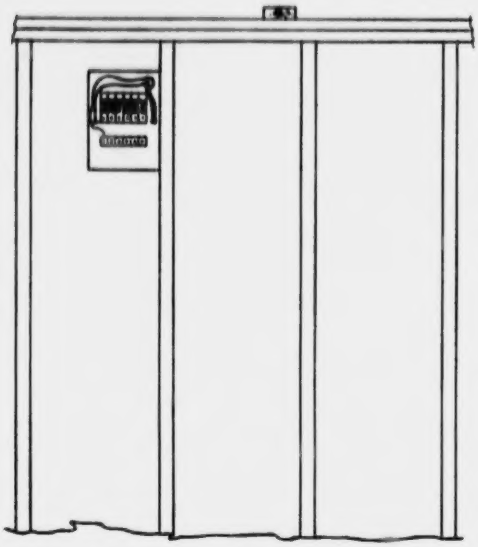
B. Procedure

1. Put on safety glasses and gather equipment and materials.

2. Mount box. (Figure 1)

   (NOTE: If mounted on a wall plate this box must be above insulation. The best place to mount the transformer is a furnace closet so you can change it without getting in the attic.)

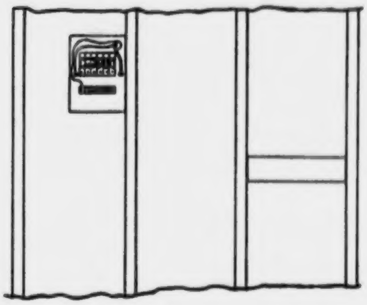
   FIGURE 1



3. Mount header. (Figure 2)

   (NOTE: It must be mounted flush with wall surface.)

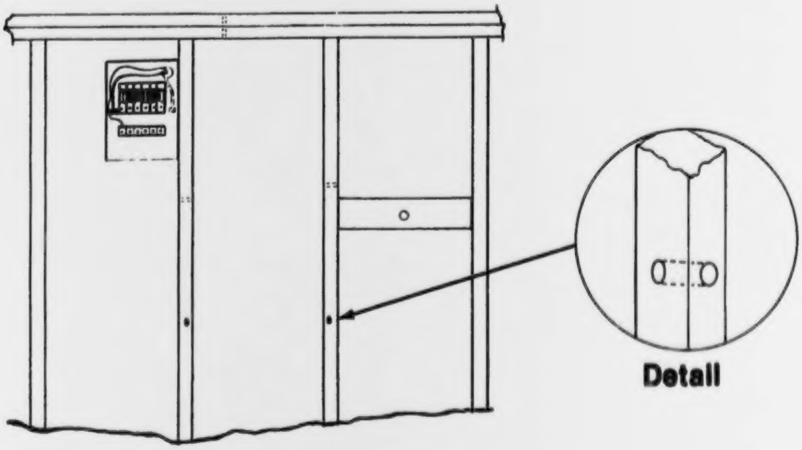
   FIGURE 2



JOB SHEET #2

4. Drill holes. (Figure 3)

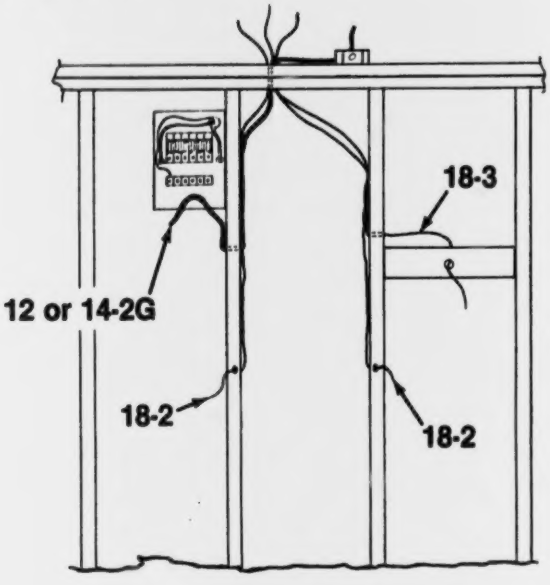
FIGURE 3



(NOTE: On a residential rough-in, button wires are drilled through at an angle in the door opening. Use GFI when drilling.)

5. Run cable. (Figure 4)

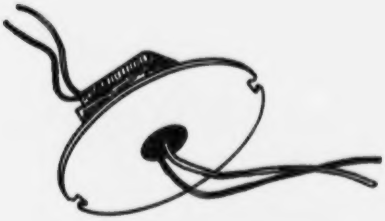
FIGURE 4


18-3
12 or 14-2G
18-2
18-2

JOB SHEET #2

6. Mount transformer to blank plate. (Figure 5)

FIGURE 5

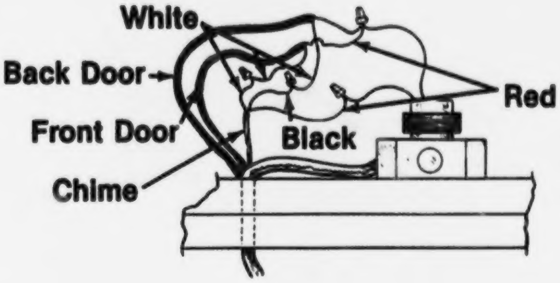


7. Connect transformer supply leads to cable from panel.

8. Mount blank plate on octagon box.

9. Make low voltage connections at transformer. (Figure 6)

FIGURE 6

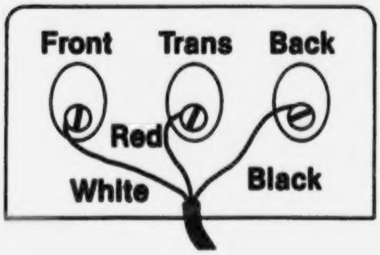

White
Back Door
Front Door
Chime
Black
Red

10. Mount chime on header.

(NOTE: Put cable through opening in subbase before securing chime.)

11. Connect conductors to chime. (Figure 7)

FIGURE 7


Front
Trans
Back
Red
White
Black

JOB SHEET #2

12. Connect buttons.

13. Connect conductors at panel.

14. Turn on breaker.

15. Push front button.

    (NOTE: A two tone chime should be heard.)

16. Push back button.

    (NOTE: A one tone chime should be heard.)

17. Have instructor evaluate work.

18. Turn off breaker.

19. Clean work area and put away all equipment and materials.

LOW VOLTAGE WIRING
UNIT XIII

JOB SHEET #3 — DETERMINE HEAT ANTICIPATOR CURRENT DRAW

A. Equipment and materials needed

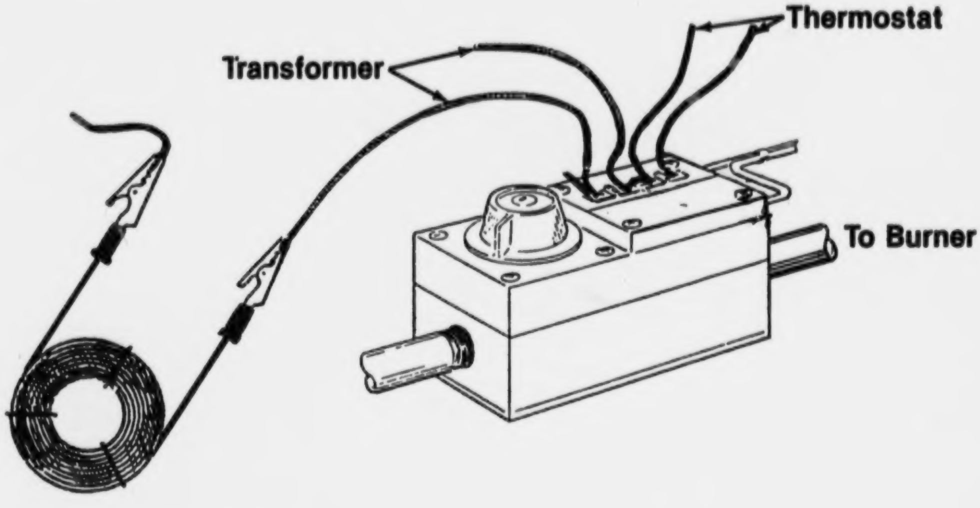
1. Ammeter
2. Coil of wire—10 loops
3. Heating unit with 24v control
4. Flat blade screwdriver
5. Safety glasses

B. Procedure

1. Disconnect power from heater.
2. Place coil of wire in series with one side of heating control. (Figure 1)

   (NOTE: This may be either a gas valve or an electric relay.)

   FIGURE 1

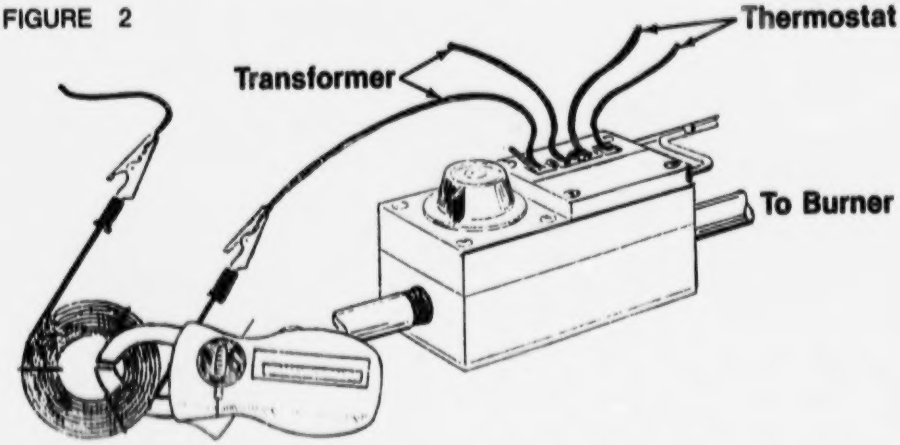


3. Turn on power.
4. Increase thermostat setting above the ambient (room) temperature.

JOB SHEET #3

5. Clamp ammeter through the coil of wire. (Figure 2)

FIGURE 2


Thermostat
Transformer
To Burner

6. Take ammeter reading.

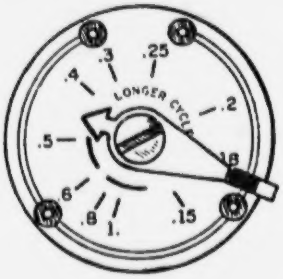
7. Divide the reading by ten.

EXAMPLE: Ammeter reading 4
4 ÷ 10 = .4

8. This is the anticipator setting.

9. Set heat anticipator on thermostat. (Figure 3)

FIGURE 3


.3
.25
.4
.2
LONGER CYCLE
.5
.18
.6
.8
1.
.15

(NOTE: Most manufacturers of heating controls will print the ampere draw of the control on the side but in case it is not the above procedure may be used to determine it.)

10. Turn off heating unit.

11. Disconnect electrical power.

12. Have instructor check the anticipator setting.

13. Clean work area and put away all equipment and materials.

LOW VOLTAGE WIRING
UNIT XIII

JOB SHEET #4 — INSTALL A WALL THERMOSTAT

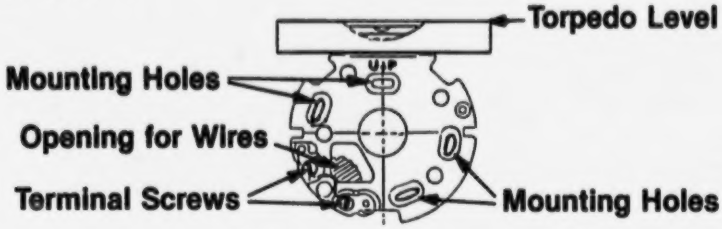
A. Equipment and materials needed

1. Flat blade screwdriver
2. Scratch awl
3. Wire strippers
4. Pocket screwdriver (small blade screwdriver)
5. Heat-cool thermostat subbase
6. Heat-cool thermostat
7. Four conductor thermostat wire
8. Torpedo level
9. Safety glasses

B. Procedure

1. Locate area on wall for thermostat.
2. Measure up from floor 54 to 60 inches.
3. Mark a spot to center subbase.
4. Hold subbase up to wall and center it.
5. Place level on subbase.
6. Check for approximate level.
7. Mark spots for mounting screw. (Figure 1)

FIGURE 1


Torpedo Level
UP
Mounting Holes
Opening for Wires
Terminal Screws
Mounting Holes

JOB SHEET #4

8. Mark spots in the center of the elongated slots.

9. Move subbase.

10. Use scratch awl to make screw holes.

11. Place subbase on wall.

12. Start screws.

13. Check for level.

14. Tighten screws and recheck level.

15. Bring thermostat wire through the proper opening.

    (NOTE: Do not have any wires crossing the center of the subbase.)

16. Strip ½" of insulation off of each conductor.

17. Connect red wire to "R" or "V" terminal.

18. Connect white wire to "W" or "H" terminal.

19. Connect green wire to "G" or "F" terminal.

20. Connect yellow wire to "Y" or "C" terminal.

    (NOTE: Some wire manufacturers have a blue wire instead of a yellow wire in their thermostat cable.)

21. Push the wires back to where they will not interfere with the thermostat.

22. Have instructor check work.

23. Align thermostat on subbase.

    (NOTE: Be sure thermostat is properly aligned before tightening to prevent cracking.)

24. Tighten thermostat screws.

    (NOTE: When removing a thermostat from a subbase, leave the screws in the retainers in the thermostat.)

25. Place cover on thermostat.

    (NOTE: If this is on a live system turn on power and check operation.)

26. Clean work area and put away all equipment and materials.

BW-779

LOW VOLTAGE WIRING
UNIT XIII

PRACTICAL TEST
JOB SHEET #1 — WIRE A TWO SWITCH LOW VOLTAGE LIGHTING CIRCUIT

STUDENT'S NAME ______________________________ DATE ______________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Care exercised in stripping outside insulation from cables.	______	______
3. All low voltage connections made correctly.	______	______
4. All supply voltage connections made correctly.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

All equipment mounted securely	4	3	2	1
Light operates on or off from both switches	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

LOW VOLTAGE WIRING
UNIT XIII

PRACTICAL TEST
JOB SHEET #2 — WIRE A TWO BUTTON CHIME CIRCUIT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Care exercised in stripping outside insulation from cable.	______	______
3. All low voltage connections made correctly.	______	______
4. All supply voltage connections made correctly.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
All equipment mounted securely	4	3	2	1
Door bell rings two notes when front door button is pushed	4	3	2	1
Door bell rings single note when back door button is pushed	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

LOW VOLTAGE WIRING
UNIT XIII

PRACTICAL TEST
JOB SHEET #3 — DETERMINE HEAT ANTICIPATOR CURRENT DRAW

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Ammeter set for proper scale.	______	______
3. Checked number of loops used.	______	______
4. Ammeter reading made correctly.	______	______
5. Conversion calculation made correctly.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Anticipator setting correct	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

LOW VOLTAGE WIRING
UNIT XIII

PRACTICAL TEST
JOB SHEET #4 — INSTALL A WALL THERMOSTAT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted thermostat base level.	______	______
3. Attached base securely.	______	______
4. Low voltage conductors stripped in such a way to prevent nick in insulation.	______	______
5. No nicks in conductors themselves.	______	______
6. Thermostat aligned and mounted correctly on base.	______	______
7. Front cover of thermostat installed correctly.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Thermostat/system works correctly in auto setting for cooling	4	3	2	1
Thermostat/system works correctly in auto setting for heating	4	3	2	1
Thermostat/system works correctly in "OFF" position	4	3	2	1
Thermostat/system works correctly in fan only position	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

LOW VOLTAGE WIRING
UNIT XIII

TEST

NAME ________________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

_____a. A device that senses temperature variations from a set point and, in turn, acts to control a circuit

_____b. Electromagnetic device for remote or automatic control

_____c. Electromagnetic cylinder that will move an iron plunger when current is applied

_____d. Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has circuits applied to it

_____e. A switch that is closed or opened only while the operator touches it

_____f. An electrical device used to step up or step down a primary voltage to a desired secondary voltage

_____g. A fire warning device commonly used in a residence that is available in two types: photoelectric or ionization

_____h. A personal communication system installed in the home to provide outside conversation with the world

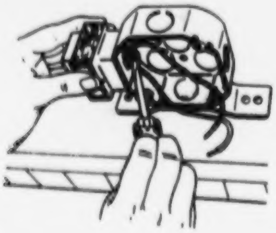
_____i. A fire warning device commonly used in a residence available in two types: fixed or rate-of-rise temperature detectors

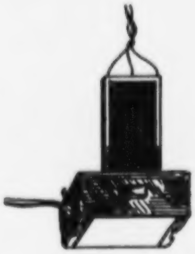
_____j. Conductor used for carrying communication signals

1. Coaxial cable
2. Heat detector
3. Momentary contact switch
4. Pull-push solenoid
5. Relay
6. Smoke detector
7. Solenoid
8. Telephone system
9. Thermostat
10. Transformer

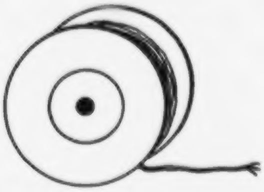
TEST

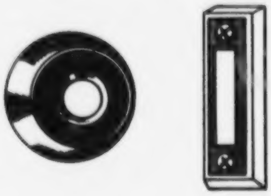
2. Identify the parts of a low voltage wiring system.





a. ______________________________ b. ______________________________





c. ______________________________ d. ______________________________

3. Describe the process that takes place during a low voltage lighting circuit off/on cycle.

____

____

____

____

4. Describe the process that takes place during the energizing of a chime circuit.

____

____

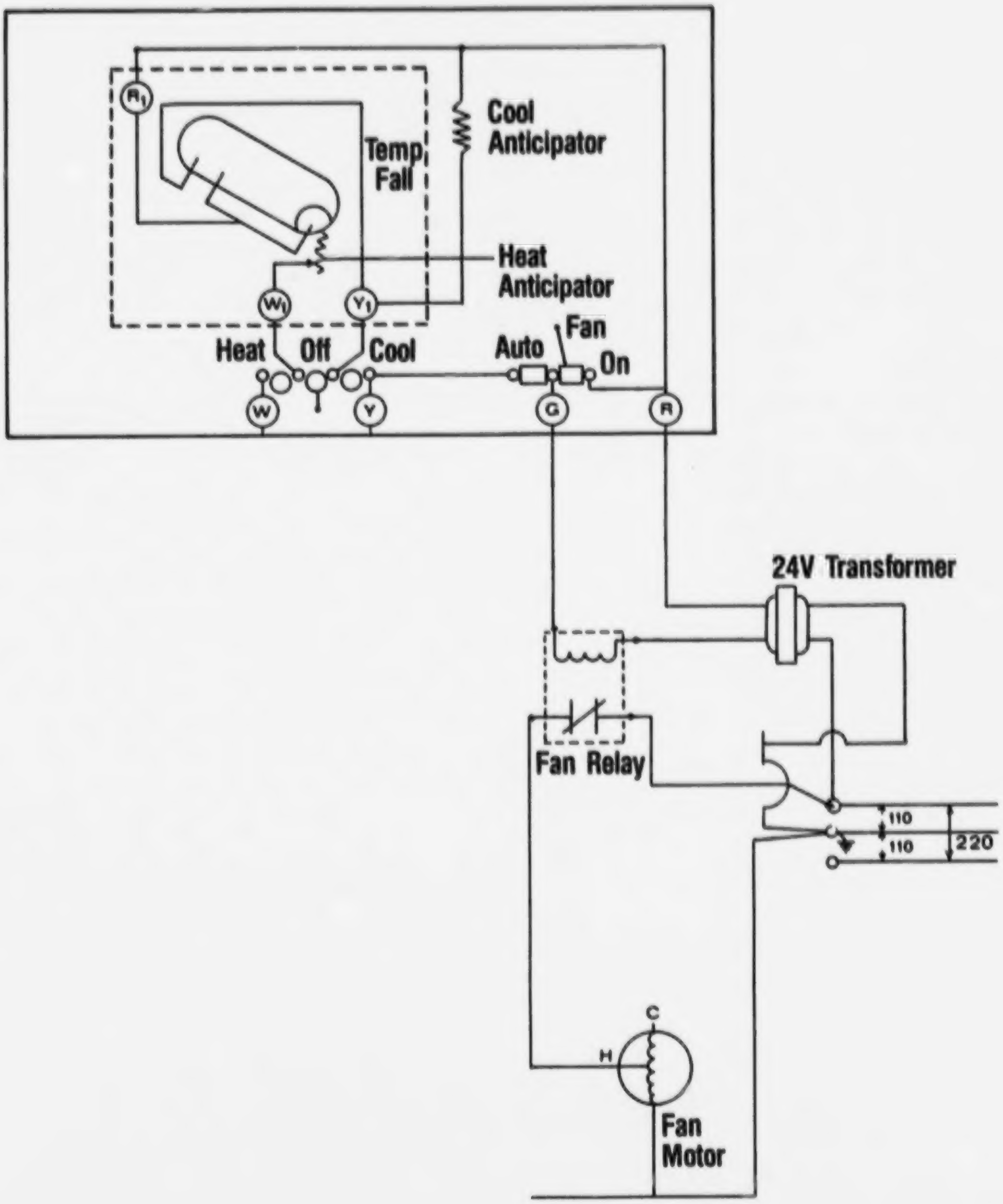
____

____

TEST

5. Complete the manual fan switching circuit below to indicate the path of current flow from the transformer through the fan control switch to close the relay and run the fan motor.

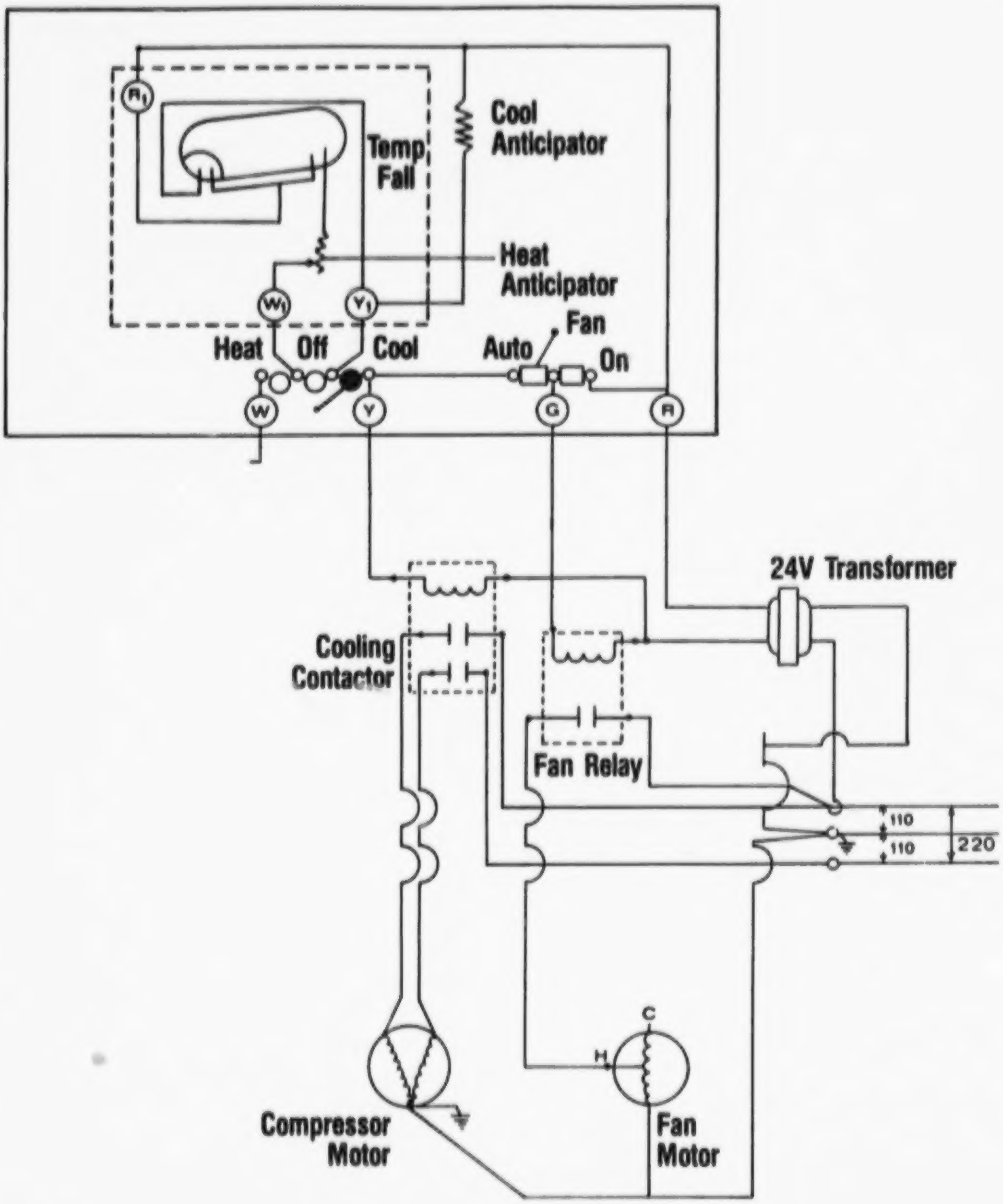
(NOTE: Let →→→ indicate current flow.)


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

TEST

6. Complete the drawing below to indicate the path of current flow with the thermostat system switch in the cool position and the fan switch on auto.

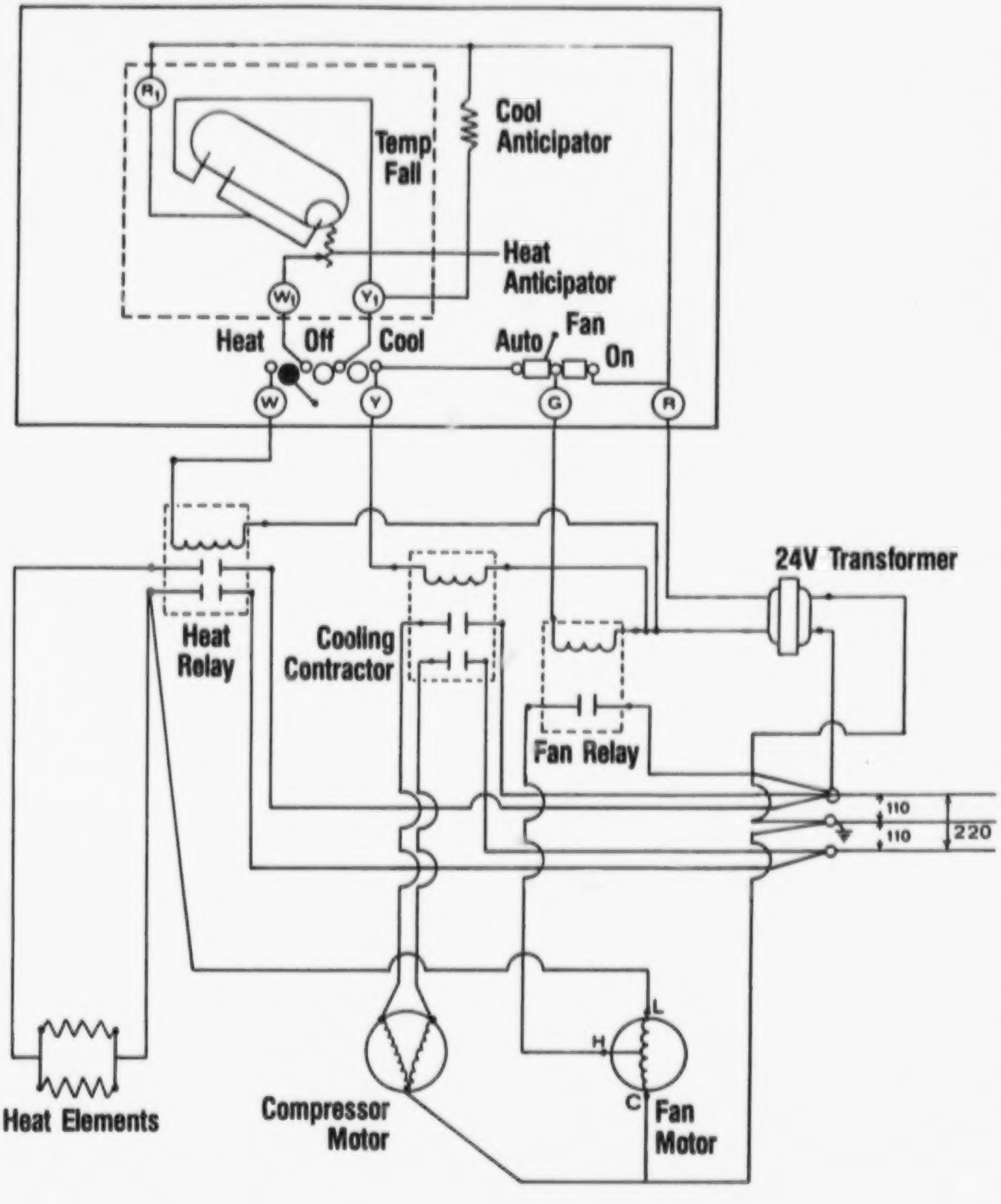
   (NOTE: Show both fan and cooling relays closed.)


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

TEST

7. Complete the drawing below to indicate the current flow with the thermostat system switch in the heat position and the fan switch on auto.

(NOTE: Show heat relay closed.)


R₁
Temp Fall
Cool Anticipator
Heat Anticipator
W₁
Y₁
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

TEST

8. Complete the following list of statements concerning anticipator circuits on low voltage thermostats by inserting the word(s) that best complete each statement.

   a. Heat and cool anticipators are installed to compensate for ____________.

   b. Cool anticipator

      1) It is wired ____________ to mercury switch.

      2) Heat causes bimetal to tilt bulb and ____________ circuit before room temperature actually reaches "on" temperature setting.

   c. Heat anticipator

      1) It is wired ____________ to mercury switch.

      2) Heat causes bimetal to tilt bulb and ____________ circuit before room temperature reaches desired room setting.

9. Match communication circuits on the right with their correct characteristics.

   (NOTE: Answers may be used more than once.)

   _____a. The point where the wiring ends and the home owner's interior wiring begins is called the demarkation point

   _____b. The circuit wiring is installed on 2 pair, 4-conductor, cable

   _____c. Communication system that allows room-to-room 2-way conversation in a residence

   _____d. Communication system whose cable types are 300 ohm or 75 ohm

   _____e. Require a separate pair of conductors all the way back to the company's switching center

   _____f. System may incorporate radio and tape playing with room monitoring

   1. Intercom
   2. Television antenna
   3. Telephone

TEST

10. Complete the following statements concerning smoke and fire alarm systems by inserting the word(s) that best complete each statement.

    a. Fire warning devices commonly used in a residence are a ____________ detector and a ____________ detector.

    b. ____________ detectors sense a specific fixed temperature a rate-of-rise.

    c. The two most common types of smoke detectors are the ____________ type and the ____________ type.

    d. ____________ is the third leading cause of accidental fatalities.

11. Select true statements concerning the operation of a garage door opener by placing an "X" in the blanks preceding the true statements.

    _____a. The opener contains a motor, radar controller, motor reversing switch, keynote speaker, radio operated controller, and electric brake.

    _____b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers.

    _____c. The push-button or key operated station consists of a normally open momentary contact switch connected by 4-wire low voltage cable to the control unit.

    _____d. The radio controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency, it will energize the motor in the opposite direction of its previous travel.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Draw a wiring diagram indicating the proper connection for bell circuit equipment. (Assignment Sheet #1)

13. Demonstrate the ability to:

    a. Wire a two switch low voltage lighting circuit. (Job Sheet #1)

    b. Wire a two button chime circuit. (Job Sheet #2)

    c. Determine heat anticipator current draw. (Job Sheet #3)

    d. Install a wall thermostat. (Job Sheet #4)

LOW VOLTAGE WIRING
UNIT XIII

ANSWERS TO TEST

1. a. 9
   b. 5
   c. 7
   d. 4
   e. 3
   f. 10
   g. 6
   h. 8
   i. 2
   j. 1

2. a. Transformer
   b. Low voltage lighting relay
   c. Low voltage cable
   d. Momentary contact switch

3. Description should include:

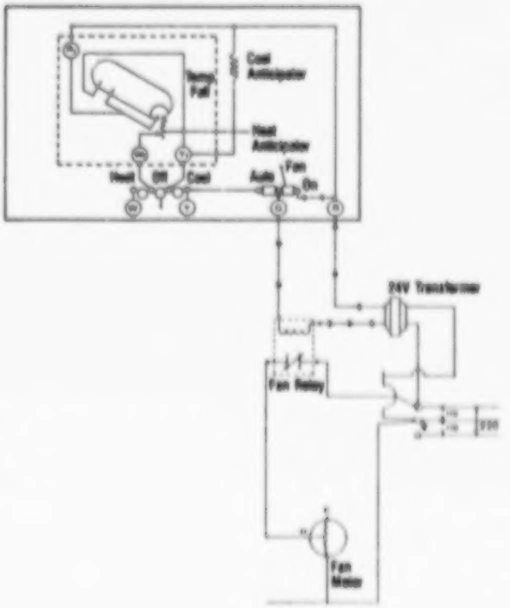
   a. "On" switch is pushed
      1) Circuit is completed to closing movement of solenoid in relay
      2) Core is moved and circuit is completed
   b. "Off" switch is pushed
      1) Circuit is completed to opening movement of solenoid in relay
      2) Core is moved and circuit is opened

4. Description should include:

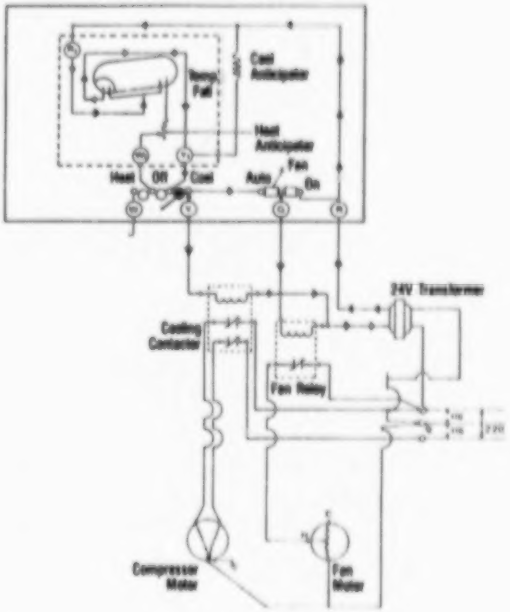
   a. Button is pushed
      1) Circuit is completed to solenoid
      2) Plunger is drawn down to chime and sound is made
   b. Button is released
      1) Circuit is open
      2) Spring pulls plunger up to upper chime and another sound is made

ANSWERS TO TEST

5.

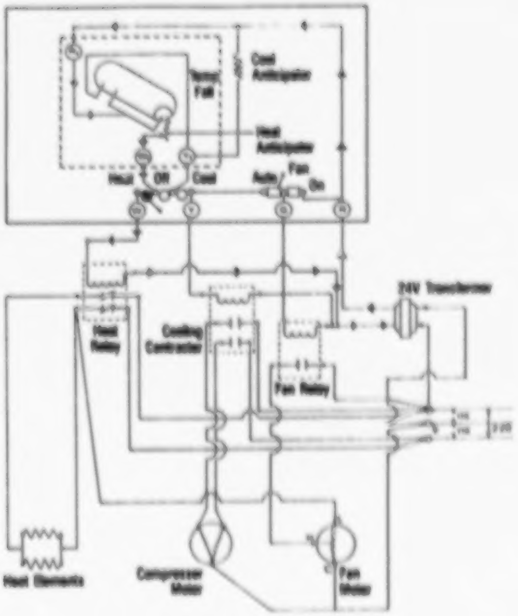

Cool Anticipator
Temp. Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
24V Transformer
Fan Relay
220
Fan Motor

6.


Cool Anticipator
Temp. Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
24V Transformer
Cooling Contactor
Fan Relay
220
Compressor Motor
Fan Motor

ANSWERS TO TEST

7.


Cool Anticipator
Temp. Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
Heat Elements
Compressor Motor
Fan Motor

8. a. Bimetallic lag
   b. 1) Parallel
      2) Close
   c. 1) In series
      2) Open

9. a. 3 d. 2
   c. 3 e. 3
   d. 1 g. 1

10. a. Heat, smoke
    b. Heat
    c. Photoelectric, ionization
    d. Fire

11. b, d

12. Evaluated to the satisfaction of the instructor

13. Performance skills evaluated to the satisfaction of the instructor

OVERCURRENT PROTECTION
UNIT XIV

UNIT OBJECTIVE

After completion of this unit, the student should be able to choose and install proper overcurrent protective devices. Competencies will be demonstrated by completing the assignment sheet, job sheet, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to overcurrent protection with their correct definitions.
2. List five types of overcurrent protective devices.
3. Describe the operation of a single element fuse.
4. Describe the operation of a dual element time delay fuse.
5. Distinguish between types of circuit breakers and their operation.
6. Select true statements concerning requirements for fuses of less than 600 volts.
7. Complete statements concerning requirements for circuit breakers of less than 600 volts.
8. List installations that require GFCI protection.
9. Calculate fuse sizes. (Assignment Sheet #1)
10. Demonstrate the ability to test cartridge fuses. (Job Sheet #1)

OVERCURRENT PROTECTION
UNIT XIV

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheet.

F. Discuss information and assignment sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheet.

H. Discuss and demonstrate the procedures outlined in the job sheet.

I. Integrate the following activities throughout the teaching of this unit:

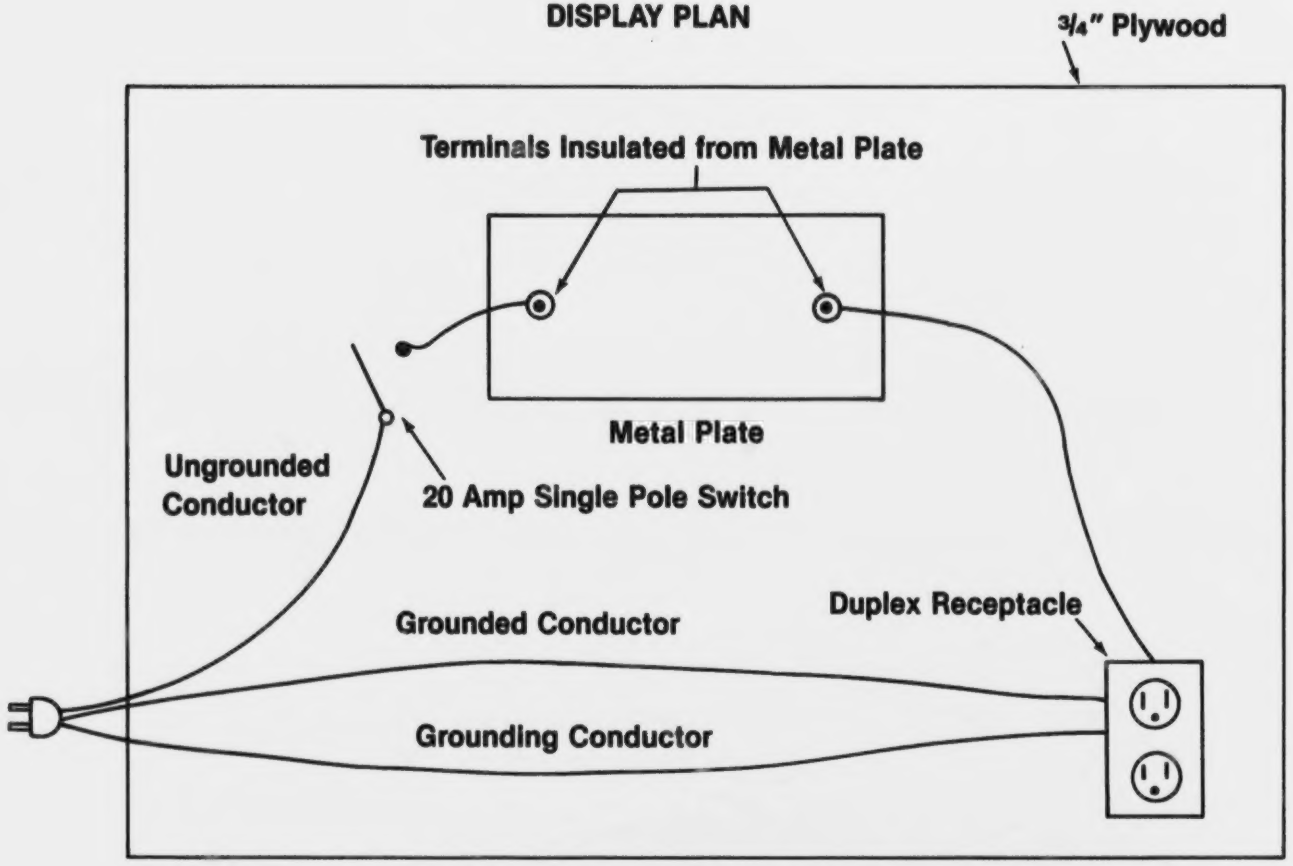
1. Construct a display to demonstrate the need for proper overcurrent protection. Design plan is included on the following page.
2. Invite Buss fuse representative to speak to the class.
3. Show cutaways of each types of fuse and breaker.
4. Obtain fuse and circuit breaker catalogs.
5. Arrange a field trip to local supply house to view varied types of overcurrent protective devices.
6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

DISPLAY PLAN


3/4" Plywood
Terminals Insulated from Metal Plate
Metal Plate
Ungrounded Conductor
20 Amp Single Pole Switch
Grounded Conductor
Duplex Receptacle
Grounding Conductor

Place various sizes of wire between terminals starting with 12 Awg and working down.

Loads can be added to the receptacle.

REFERENCES USED IN WRITING THIS UNIT

A. *Buss Full Line Catalog (FLC).* Bussmann Division, McGraw-Edison Co., 1985.

B. *Maintenance of Low Voltage Circuit Breakers and Switch Gear.* Rockville, MD: NUS Training Corporation, a Halliburton Company, 1981.

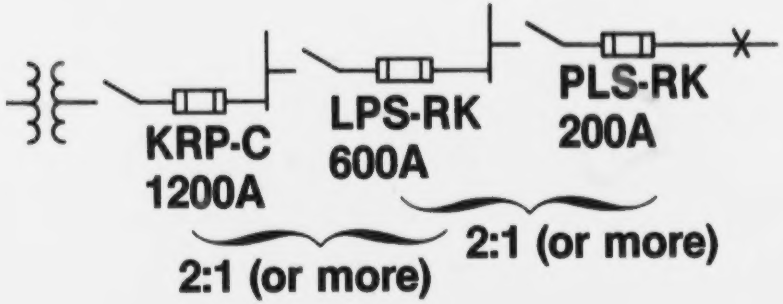
C. *National Electrical Code, 1987.* Quincy, MA: National Fire Protection Association, 1986.

D. Stallcup, James G. *Illustrated Changes of the 1987 NEC.* Homewood, IL: American Technical Publishers, Inc., 1986.

E. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

F. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

Selective Coordination



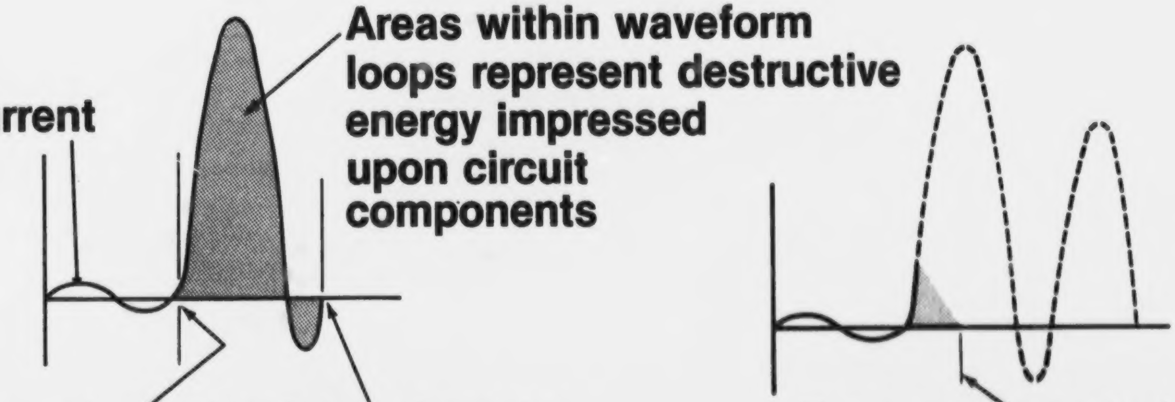
KRP-C
1200A

LPS-RK
600A

PLS-RK
200A

2:1 (or more)

2:1 (or more)



Normal
Load Current

Areas within waveform loops represent destructive energy impressed upon circuit components

Initiation of
Short-Circuit
Current

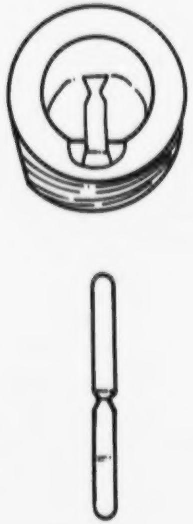
Circuit breaker trips
and opens short-circuit
in about 1 cycle

Fuse opens and clears
short-circuit in less
than ½ cycle

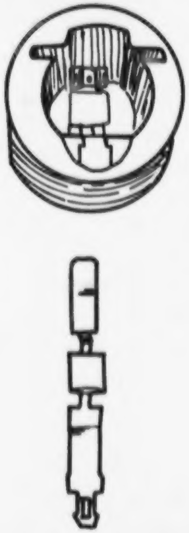
Fuse Elements

Fuse Elements

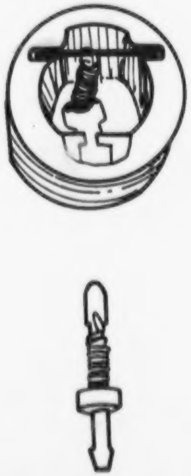
Description



Non-Type-Delay
Element is a simple fusible, metal link. For general purpose circuit protection.
Quickly opens (blows) when short-circuit or overload occurs. Use for lighting and other non-motor circuits.



Time Delay, Loaded Link
Heat absorbing metal bead on element link for time delay.
Passes motor overload starting currents without needlessly opening.



Time-Delay, Dual-Element
For all-purpose application. Like two fuses in one. A simple link element for short-circuits and dangerous overloads plus a series-connected element which lets the harmless overload starting currents of motors pass without opening. Uses less energy, operates cooler, provides superior protection.

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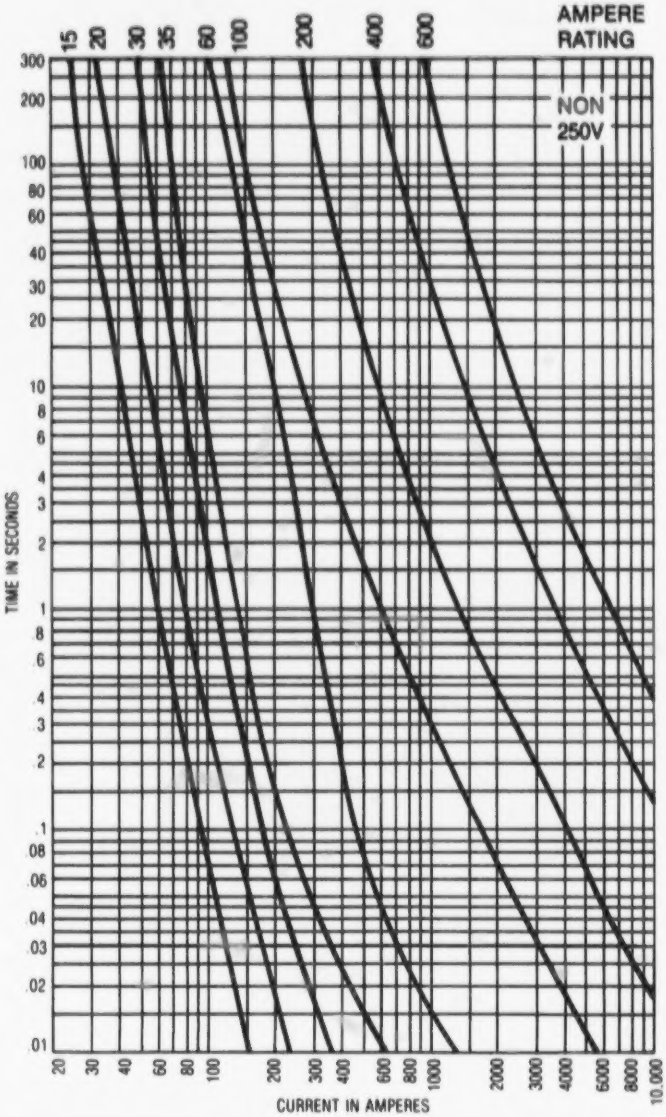
Time-Current Curve-Average Melt For One Time General Purpose
NON
(Single Element Fuse)



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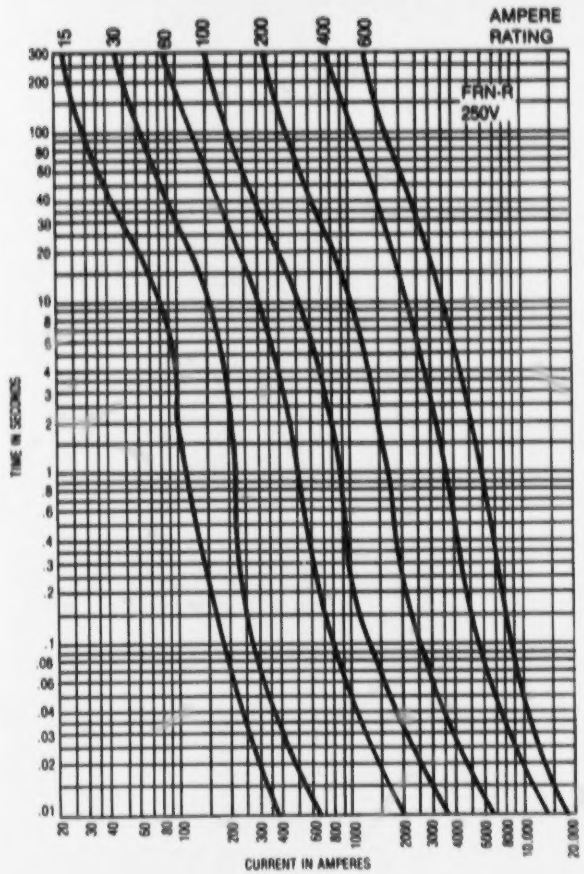
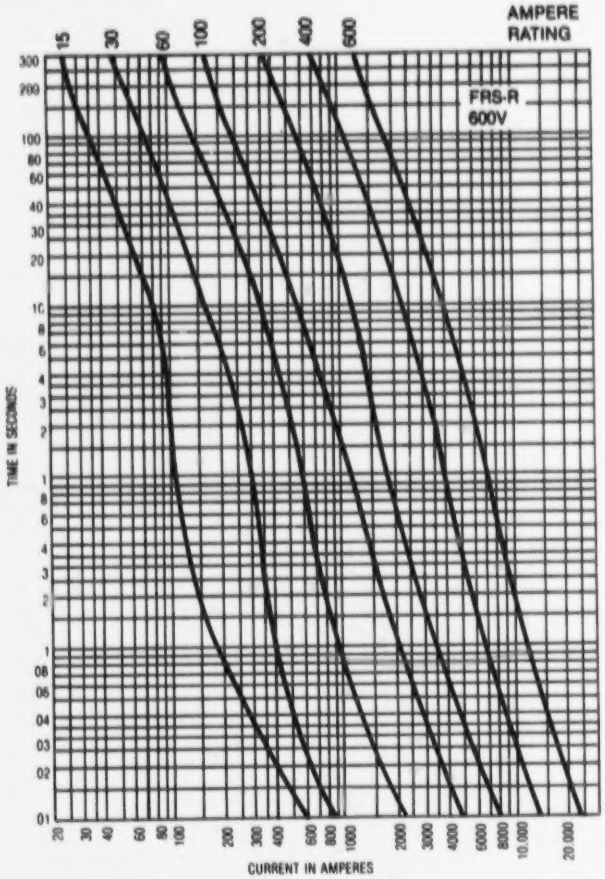
Time-Current Curve-Average Melt For Dual-Element Time-Delay FRN-R & FRS-R





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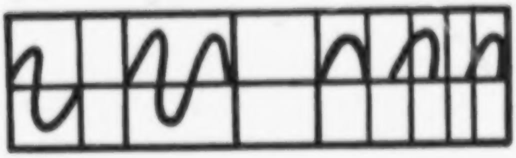
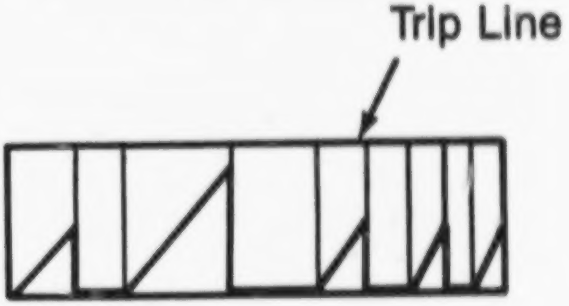
TM 4
Objective III

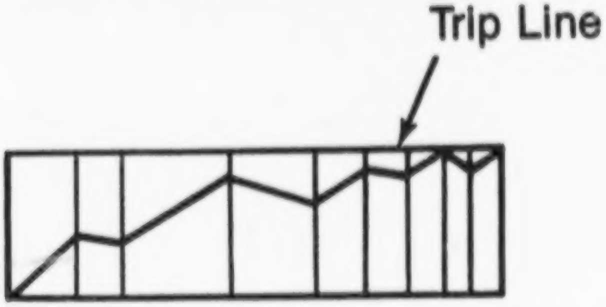
Ground Fault Relaying



Intermittent Ground Fault



Ground Fault Relay Without Memory — Resets After Each Arc



Ground Fault Relay with Memory Circuit — Does Not Reset So Quickly and Trips to Save Expensive Power Equipment

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OVERCURRENT PROTECTION
UNIT XIV

INFORMATION SHEET

I. **Terms and definitions**

   A. Air circuit breaker — Breaker in which all parts operate in air

   B. Amperage rating — Maximum current-carrying capacity of a device

   C. Blade type cartridge fuse — Fuse with flat contact blades on a cylindrical case

   D. Circuit breaker — Automatic overcurrent device that trips on overloads or shorts and is resettable

   E. Current-limiting overcurrent protective device — Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

   F. Device — Electrical equipment that carries or transfers current but does not use it

   G. Dual-element fuse — Fuse that has a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without having the fuse

   (NOTE: Dual element fuses should not be confused with fuses with two renewable links in a fuse cartridge.)

   H. Edison base plug fuse — Fuse with a base that fits the same sockets as a regular based incandescent bulb

   I. Fault current — Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

   J. Ferrule type cartridge fuse — Fuse with metal caps on a cylindrical case

   K. Ground fault — Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

   L. Ground fault circuit interrupter — Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 amperes

INFORMATION SHEET

M. Interrupting rating — Maximum available short-circuit current that an overcurrent device can safely interrupt without danger to itself

N. Oil circuit breaker — Load interrupter in which the interrupting contacts operate submerged in transformer oil

O. Overcurrent protection — Weak link in the circuit that limits the amperage to a specified amount

P. Overload — Larger than normal current flowing within the normal current path

Q. Selective coordination — The use of interrupting devices sized and installed so that the one nearest a fault or overload will open before any of the larger upstream devices open

R. Short circuit — Larger than normal current flowing outside the normal current path

S. Single element fuse — Fuse that contains only one element and is not designed to carry an overload

T. Time current curve — Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

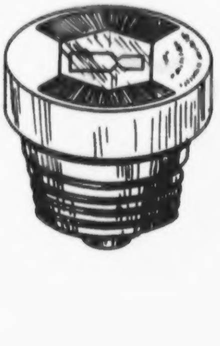
U. Type "S" plug fuse — Fuse with special size limiting characteristics for each amperage range

(NOTE: Refer to NEC Article 240-51B.)

V. Voltage rating — Maximum voltage at which a device is designed to operate

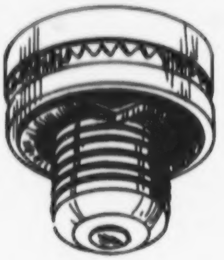
II. Types of overcurrent protective devices

A. Edison base plug fuse



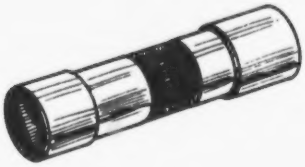
INFORMATION SHEET

B. Type "S" plug fuse (Fustat)



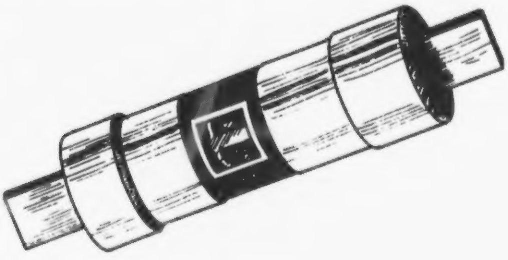
C. Ferrule type cartridge fuse

(NOTE: Standard ampacities are 15, 20, 30, 40, and 60 amps.)



D. Blade type cartridge fuse

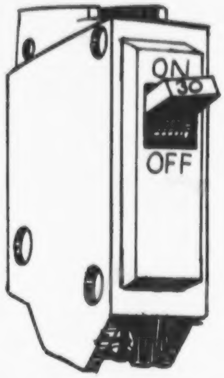
(NOTE: Standard ampacities start at 65 amps.)



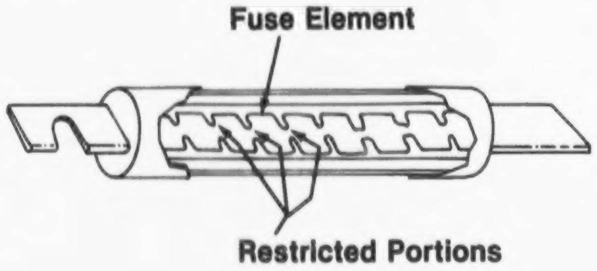
INFORMATION SHEET

E. Circuit breaker

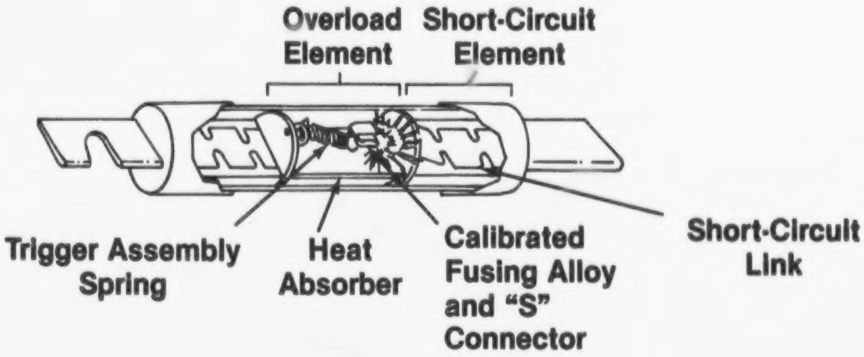
(NOTE: Standard ampacities start at 15 amp.)



III. **Operation of a single element fuse** — Under sustained overload conditions, the restricted portions of the fuse element heat to their predetermined melting point, thus opening and interrupting the flow of current.


Fuse Element
Restricted Portions

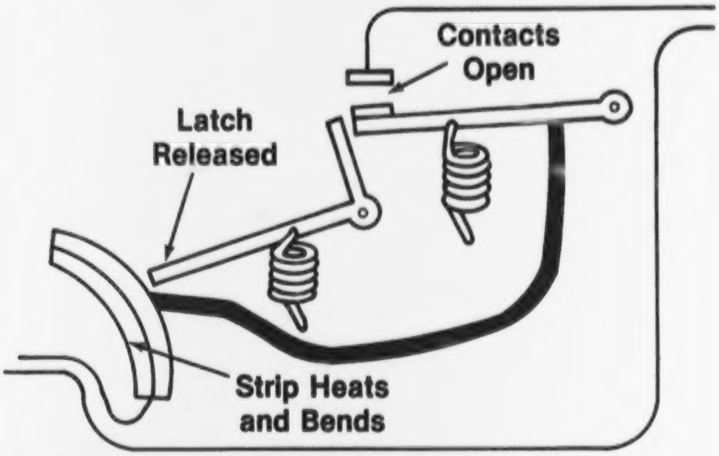
IV. **Operation of a dual element time delay fuse** — Under sustained overload conditions, the trigger spring fractures the fusing alloy and releases the "connector."


Overload Element
Short-Circuit Element
Trigger Assembly Spring
Heat Absorber
Calibrated Fusing Alloy and "S" Connector
Short-Circuit Link

INFORMATION SHEET

V. **Types of circuit breakers and their operation**

A. Thermal trip — If current flow exceeds the rated limit of the breaker, the bimetallic strip heats and bends. As the strip bends, the latching mechanism is tripped and the contacts open.


Contacts Open
Latch Released
Strip Heats and Bends

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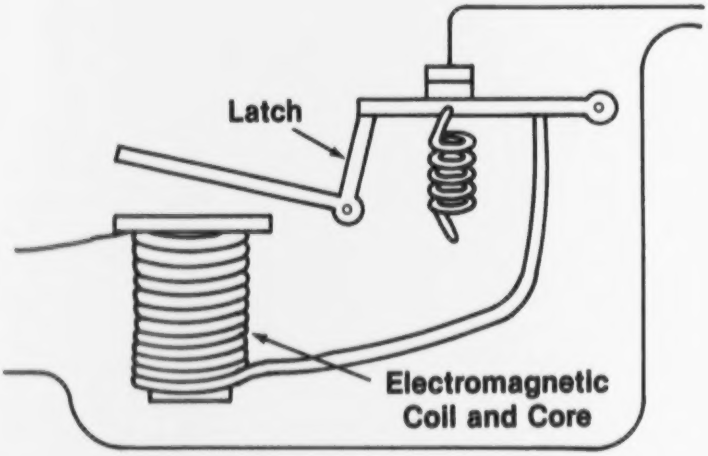
B. Electromagnetic trip — As current flows through the breaker, it creates a magnetic field within the coil. During sustained overload conditions, the magnetic field intensifies and draws the core into the coil. The metal trip bar is attracted to the core forcing the latch to move, thus opening the contacts.


Latch
Electromagnetic Coil and Core

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INFORMATION SHEET

VI. **Requirements for fuses of less than 600 volts**

(NOTE: Refer to NEC Article 240.)

A. Plug fuses shall not be used in circuits exceeding 125 volts between conductors.

B. Fuses shall be marked with their amperage rating.

C. Plug fuses shall be classified 0 to 30 amperes.

D. Edison base plug fuses may be used only as replacements.

E. Type "S" fuses (fustats) shall be classified at not over 125 volts.

(NOTE: Refer to NEC Article 240-51B.)

F. Type "S" fuses shall be classified at 0 to 15, 16 to 20, and 21 to 30 amperes.

G. Different ampere classes of type "S" fuses are not interchangeable.

H. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer.

VII. **Requirements for circuit breakers of less than 600 volts**

(NOTE: Refer to NEC Article 240.)

A. Circuit breakers shall be capable of being manually tripped and set.

(NOTE: Where used as switches in 120 and 277 volt flourescent lighting circuits, breakers shall be approved for such switching duty and shall be marked "SWD".)

B. Circuit breakers shall have a visible "off" and "on" indication.

C. The breaker shall be designed so that any change of its trip point (ampere rating) or time required for operation will require dismantling or the breaking of a seal.

D. Circuit breakers shall be marked with their ampere rating in a manner that will be durable and visible by removal of a trim or cover.

E. Every circuit breaker having an interrupting rating other than 5000 amperes shall have its interrupting rating shown on the circuit breaker.

INFORMATION SHEET

VIII. Installation that require GFCI protection

(NOTE: Refer to NEC Articles 210, 305, and 680. GFCI protection may be referenced in additional articles also.)

A. All 125-volt 15 and 20 ampere receptacles installed in bathrooms

B. All 125-volt 15 or 20 ampere receptacles installed in garages

C. All 125-volt 15 and 20 ampere receptacles installed outdoors in direct grade level

D. At least one 125-volt 15 or 20 ampere receptacle installed in a basement

E. All 125-volt 15 and 20 ampere receptacles installed within 6 feet of a kitchen sink, above counter tops

F. All 125-volt 15 or 20 ampere construction receptacles

G. Receptacles located within 15 feet of the inside walls of a swimming pool

OVERCURRENT PROTECTION
UNIT XIV

ASSIGNMENT SHEET #1 — CALCULATE FUSE SIZES

NAME ______________________________ SCORE ______________

The electrical worker should be able to calculate appropriate fuse sizes by referring to reference materials and charts and by calculating percentages correctly.

Directions: Use the guidelines for sizing dual-element time-delay fuses and the line diagram that follows to calculate fuse amperages in the problems that follow. Show your work.

Refer to *NEC* Article 240-6 for standard ampere ratings for fuses.

Dual-Element Time-Delay Fuse

1 **Main Service**. Size fuse according to method in **4**.

2 **Feeder Circuit With No Motor Loads**. The fuse size must be at least 125 percent of the continuous load plus 100 percent of the noncontinuous load. Do not size the fuse larger than the ampacity of the conductor.

3 **Feeder Circuit With All Motor Loads**. Size the fuse at 150 percent of the full-load current of the largest motor plus full-load current of all other motors.

4 **Feeder Circuit With Mixed Loads**. Size fuse at sum of:

a. 150 percent of the full-load current of the largest motor.
b. 100 percent of the full-load current of all other motors.
c. 125 percent of the continuous nonmotor load.
d. 100 percent of the noncontinuous nonmotor load.

5 **Branch Circuit With No Motor Load**. The fuse size must be at least 125 percent of the continuous load plus 100 percent of the noncontinuous load. Do not size the fuse larger than the ampacity of the conductor.

6 **Motor Branch Circuit With Overload Relays**. Where overload relays are sized for motor running overload protection, the following fuses provide back-up protection and short-circuit protection:

a. Motor 1.15 service factor or 40°C rise: size fuse at 125 percent of motor full-load current or next higher standard size.

b. Motor less than 1.15 service factor or 40°C rise: size the fuse at 115 percent of the motor full-load current or the next higher standard fuse size.

ASSIGNMENT SHEET #1

7 Motor Branch Circuit With Fuse Protection Only.
Where the fuse is the only motor protection, the following fuses provide motor running overload protection and short-circuit protection:

a. Motor 1.15 service factor or 40°C rise: size the fuse at 110 percent to 125 percent of the motor full-load current.

b. Motor less than 1.15 service factor or over 40°C rise:
size fuse at 100 percent to 115 percent of motor full-load current.

8 Large Motor Branch Circuit. Fuse larger than 600 amps. For large motors, size KRP-C HI-CAP time-delay fuse at 150 percent to 225 percent of the motor full-load current, depending on the starting method such as part-winding starting or reduced-voltage starting.

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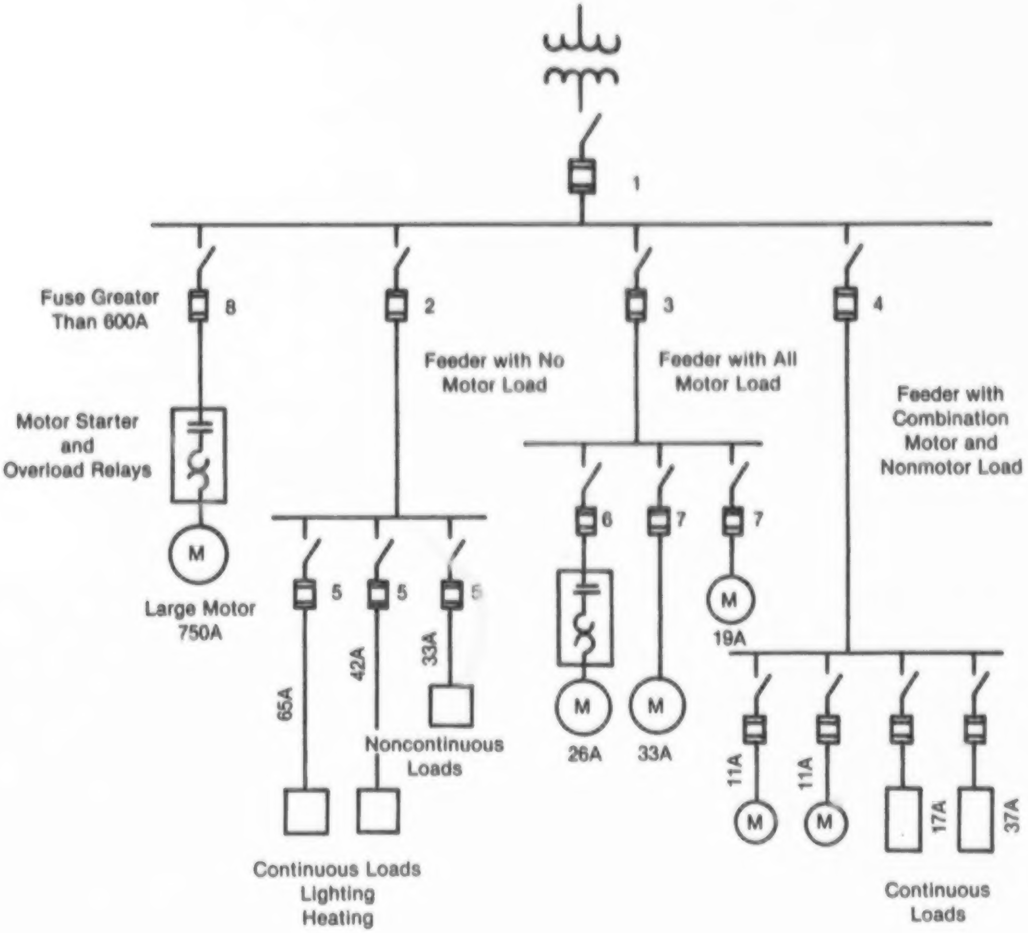
ASSIGNMENT SHEET #1


1
Fuse Greater Than 600A
8
2
3
4
Feeder with No Motor Load
Feeder with All Motor Load
Feeder with Combination Motor and Nonmotor Load
Motor Starter and Overload Relays
M
Large Motor 750A
5
5
5
65A
42A
33A
Noncontinuous Loads
Continuous Loads Lighting Heating
6
7
7
M
19A
M
26A
M
33A
11A
11A
M
M
17A
37A
Continuous Loads

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ASSIGNMENT SHEET #1

A. What fuse range may be used with the large motor branch circuit?

Fuse = ____________________ to ____________________ amps

B. What fuse size is required for the 65-ampere continuous load?

Fuse = ____________________ amps

C. What fuse size is required for the feeder circuit with no motor loads?

Fuse = ____________________ amps

D. What fuse size is required for the feeder circuit with all motor loads?

Fuse = ____________________ amps

ASSIGNMENT SHEET #1

E. If the service factor is 1.15, what fuse size is required for the motor branch circuit with overload relay?

Fuse = ____________________ amps

F. If the service factor is 1.15, what fuse range may be used for the branch circuit with the 33-ampere load?

Fuse = ____________________ amps

G. What fuse size is required for the feeder circuit with combination motor and nonmotor loads?

Fuse = ____________________ amps

H. What size main service fuse is required?

Fuse = ____________________ amps

OVERCURRENT PROTECTION
UNIT XIV

ANSWERS TO ASSIGNMENT SHEET #1

A. 1,200 to 2,000

B. 90

C. 175

D. 100

E. 35

F. 40 to 45

G. 100

H. 1,600

OVERCURRENT PROTECTION
UNIT XIV

JOB SHEET #1 — TEST CARTRIDGE FUSES

A. Equipment and materials needed

1. Eye protection
2. Live disconnect
3. Several fuses, both good and bad
4. Voltmeter

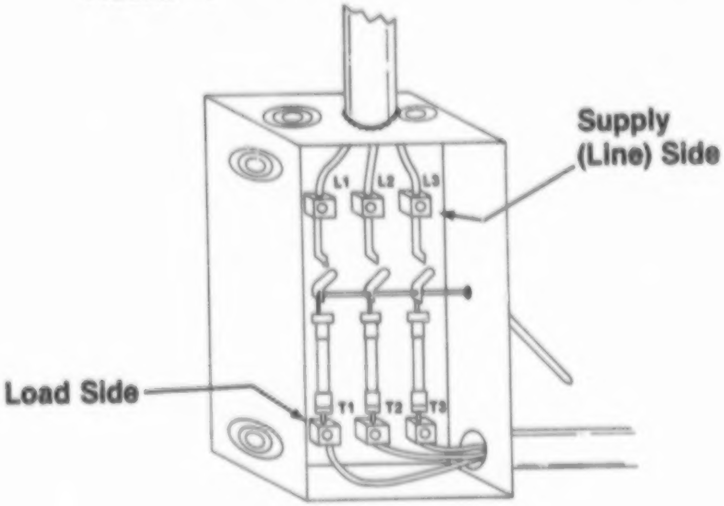
B. Procedure

(CAUTION: Live voltages are present during this test. Proper safety precautions should be observed.)

1. Put on eye protection.
2. Deenergize disconnect.
3. Install fuses.
4. Energize disconnect and leave disconnect door open.
5. Set voltmeter to appropriate voltage scale.
6. Test voltage on supply side of disconnect. (Figure 1)

(NOTE: On a 208-volt, three-phase disconnect, 208 volts should be present from L1 to L2, L1 to L3, and L2 to L3.)

FIGURE 1



JOB SHEET #1

7. Place voltmeter probe #1 on L1 terminal and probe #2 on T2 terminal; voltage should be 208 volts.

8. Move probe #2 to T3 terminal; voltage should be 208 volts.

9. Move probe #1 to L2 terminal and probe #2 to T1 terminal; voltage should be 208 volts.

10. Move probe #2 to T3 terminal; voltage should be 208 volts.

11. Move probe #1 to L3 terminal and probe #2 to T1 terminal; voltage should be 208 volts.

12. Move probe #2 to T2 terminal; voltage should be 208 volts.

    (NOTE: A lower voltage or no voltage indicates a bad fuse. When meter shows low or no voltage, probe #2 will always be under the fuse that is bad.)

13. Repeat steps 2 through 12 using different fuses.

    (NOTE: Have instructor evaluate work.)

14. Clean work area; put away all equipment and materials.

BW-833

OVERCURRENT PROTECTION
UNIT XIV

PRACTICAL TEST
JOB SHEET #1 — TEST CARTRIDGE FUSES

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Tested line voltage properly.	______	______
3. Probes placed on L1 and T2.	______	______
4. Probes placed on L1 and T3.	______	______
5. Probes placed on L2 and T1.	______	______
6. Probes placed on L2 and T3.	______	______
7. Probes placed on L3 and T1.	______	______
8. Probes placed on L3 and T2.	______	______
9. Determined which fuse was blown properly.	______	______
10. Checked in/put away tools and materials.	______	______
11. Cleaned the work area.	______	______
12. Used proper tools correctly.	______	______
13. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
14. Practiced safety rules throughout procedure.	______	______
15. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Used correct meter function	4	3	2	1
Located blown fuse	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

OVERCURRENT PROTECTION
UNIT XIV

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

_____a. Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

_____b. Maximum voltage at which a device is designed to operate

_____c. Larger than normal current flowing outside the normal current path

_____d. Larger than normal current flowing within the normal current path

_____e. Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

_____f. Fuse that contains only one element and is not designed to carry an overload

_____g. Fuse that has within it a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without harming the fuse

_____h. The use of interrupting devices sized and installed so that the one nearest the fault or overloaded machine will open before any of the larger upstream devices open

_____i. Maximum current-carrying capacity of a device

_____j. Breaker in which all parts operate in air

_____k. Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

1. Air circuit breaker
2. Amperage rating
3. Blade type cartridge fuse
4. Circuit breaker
5. Current-limiting overcurrent protective device
6. Device
7. Dual-element fuse
8. Edison base plug fuse
9. Fault current
10. Ferrule type cartridge fuse
11. Ground fault
12. Ground-fault circuit interrupter
13. Interrupting rating
14. Oil circuit breaker
15. Overcurrent protection

TEST

______l. Automatic overcurrent device that trips on overloads or shorts and is resettable

______m. Fuse with special size limiting characteristics for each amperage range

______n. Fuse with flat contact blades on a cylindrical case

______o. Electrical equipment that carries or transfers current but does not use it

______p. Fuse with a base that fits the same socket as a regular based incandescent bulb

______q. Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

______r. Fuse with metal caps on a cylindrical case

______s. Breaker designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 amperes

______t. Maximum available short-circuit current that an overcurrent device can safely interrupt without damage to itself

______u. Load interrupter in which the interrupting contacts operate submerged in transformer oil

______v. Weak link in the circuit that limits the amperage to a specified amount

16. Overload
17. Selective coordination
18. Short circuit
19. Single-element fuse
20. Time-current curve
21. Type "S" plug fuse
22. Voltage rating

2. List five types of overcurrent protective devices.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

TEST

3. Describe the operation of a single element fuse.

____

____

____

4. Describe the operation of a dual element time delay fuse.

____

____

____

____

5. Distinguish between types of circuit breakers and their operation by placing a "T" for thermal trip next to its correct operation.

_____a. As current flows through the breaker, it creates a magnetic field within the coil. During sustained overload conditions, the magnetic field interferes and draws the core into the coil. The metal trip bar is attracted to the core forcing the latch to move, thus opening the contacts.

_____b. If current flow exceeds the rated limit of the breaker, the bimetallic strip heats and bends. As the strip bends, the latching mechanism is tripped and the contacts open.

6. Select true statements concerning requirements for fuses of less than 600 volts by placing an "X" in the blanks preceding the true statements.

_____a. Plug fuses should be used in circuits exceeding 125 volts between conductors.

_____b. Fuses shall be marked with their amperage rating.

_____c. Edison base plug fuses shall be classified 0 to 20 amperes.

_____d. Plug fuses may be used only as replacements.

_____e. Type "S" fuses (fustats) shall be classified at not over 125 volts.

_____f. Different ampere classes of Type "S" fuses are interchangeable.

_____g. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer.

TEST

7. Complete the following statements concerning requirements for circuit breakers of less than 600 volts by inserting the words which best complete each statement.

   a. Circuit breakers shall be capable of being manually ______________ and ______________ .

   b. Circuit breakers shall have a visible ______________ and ______________ indication.

   c. The breaker shall be designed so that any change of its trip point (ampere rating) or time required for operation will require ______________ or the breaking of a seal.

   d. Circuit breakers shall be marked with their ampere rating in a manner that will be ______________ and ______________ by removal of a trim or cover.

   e. Every circuit breaker having an interrupting rating other than ______________ amperes shall have its interrupting rating shown on the circuit breaker.

8. List five installations that require GFCI protection.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

9. Calculate fuse sizes. (Assignment Sheet #1)

10. Demonstrate the ability to test cartridge fuses. (Job Sheet #1)

OVERCURRENT PROTECTION
UNIT XIV

ANSWERS TO TEST

1.

a.	11	f.	19	k.	5	p.	8	u.	14
b.	22	g.	7	l.	4	q.	9	v.	15
c.	18	h.	17	m.	21	r.	10		
d.	16	i.	2	n.	3	s.	12		
e.	20	j.	1	o.	6	t.	13		

2.
   a. Edison base plug fuse
   b. Type "S" plug fuse (fustat)
   c. Ferrule type cartridge fuse
   d. Blade type cartridge fuse
   e. Circuit breaker

3. Under sustained overload conditions, the restricted portions of the fuse element heat to their predetermined melting point, thus opening and interrupting the flow of current.

4. Under sustained overload conditions the trigger spring fractures the fusing alloy and releases the "S" connector.

5. b

6. b, e, g

7.
   a. Tripped, set
   b. Off, on
   c. Dismantling
   d. Durable, visible
   e. 5000

8. Any five of the following:

   a. Bathrooms
   b. Garages
   c. Outdoors in direct grade level
   d. At least one GFCI receptacle in basements
   e. Within six feet of kitchen sinks
   f. Construction sites
   g. Within fifteen feet of inside walls of a pool

9. Evaluated to the satisfaction of the instructor

10. Performance skills evaluated to the satisfaction of the instructor

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify parts and components of load centers and safety switches as well as install them. Competencies will be demonstrated by completing the assignment sheet, job sheets, and unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to load centers and safety switches with their correct definitions.
2. Identify types of safety switch enclosures.
3. Identify safety switch system configurations.
4. Identify types of load centers and enclosures.
5. Match common load center accessories with their uses.
6. Label the parts of a fusible load center.
7. Label the parts of a breaker load center.
8. Identify common panel bus configurations.
9. Select true statements concerning safety rules for working around load centers and safety switches.
10. Using the NEC, answer questions related to load centers. (Assignment Sheet #1)

OBJECTIVE SHEET

11. Demonstrate the ability to:

    a. Install a safety switch. (Job Sheet #1)

    b. Wire a load center or breaker panel. (Job Sheet #2)

    c. Wire a receptacle circuit to a load center. (Job Sheet #3)

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheet.

F. Discuss information and assignment sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

   1. Tour school and residential construction sites to view various load center and safety switch installations.

   2. Acquire load centers and safety switches to show the class.

   3. Stress importance of branch circuit overcurrent protection and relate to unit on conductors.

   4. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN WRITING THIS UNIT

A. *Digest*. Park Ridge, IL: Square D Company, 1987.

B. *Industrial Control Catalog, 1986-87*. Milwaukee, WI: Cutter-Hammer Products, 1986.

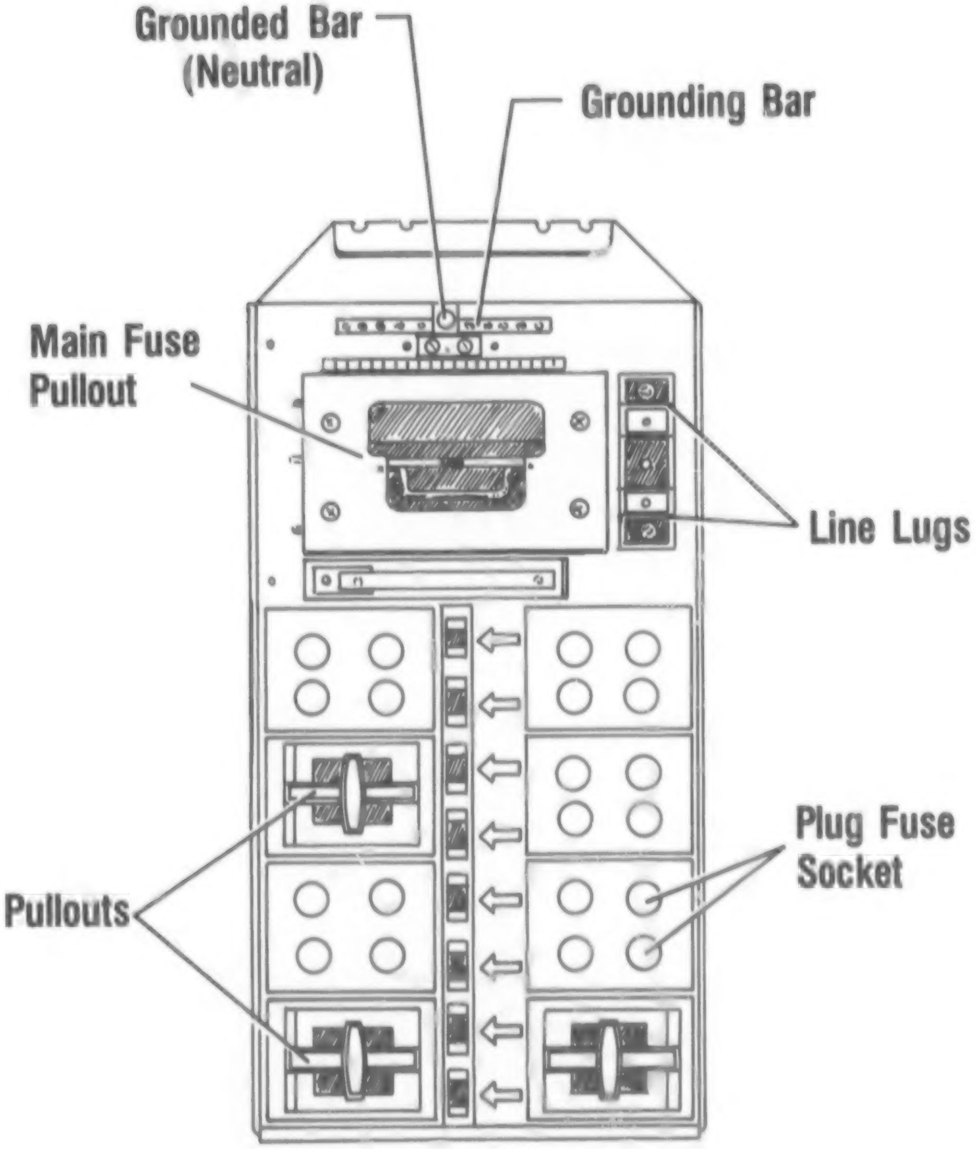
C. *National Electrical Code, 1987*. Quincy, MA: National Fire Protection Association, 1986.

D. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

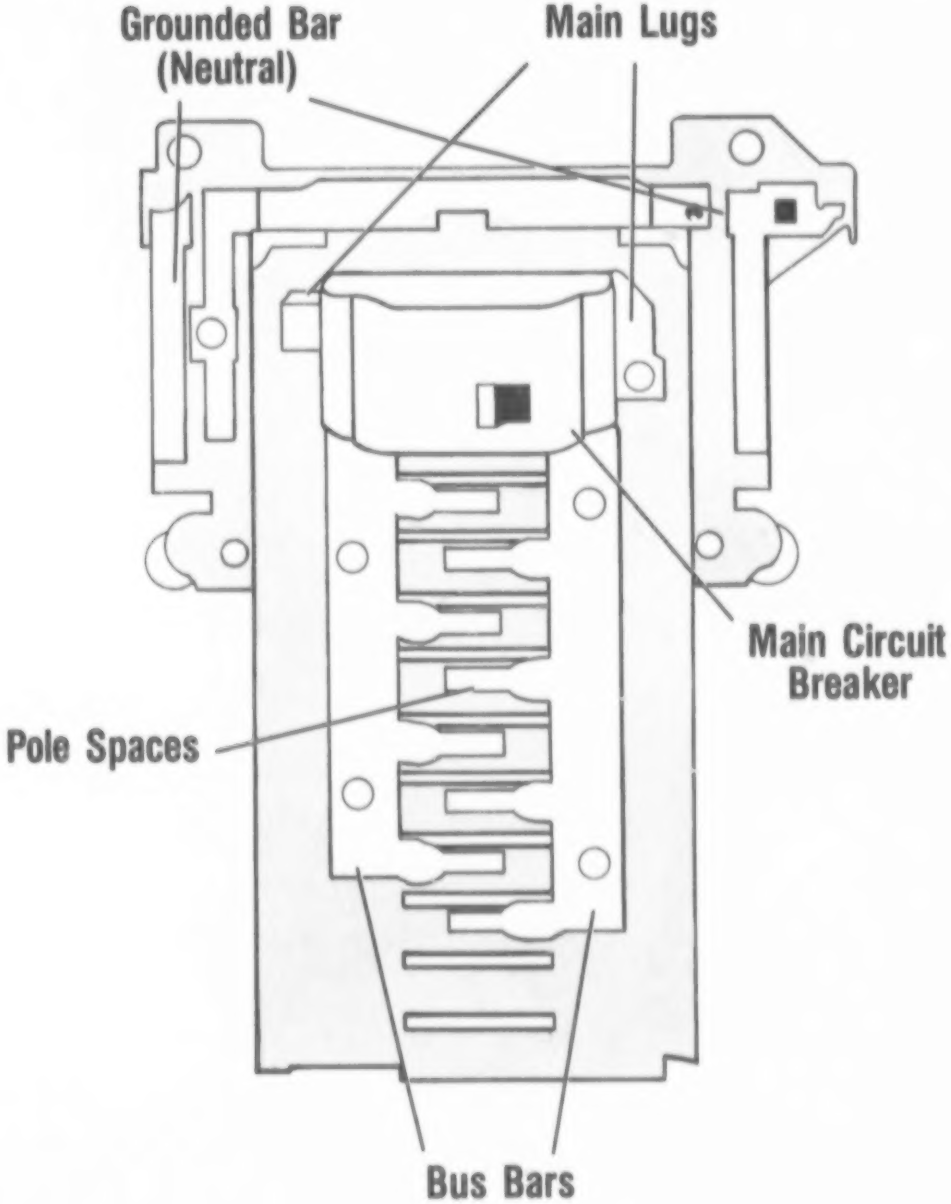
SUGGESTED SUPPLEMENTAL MATERIAL

Catalog — *Selection Guide*. Cutter-Hammer/Power Distribution Products, 4201 N. 27th Street, Milwaukee, Wisconsin.

Parts of a Fusible Load Center


Grounded Bar
(Neutral)
Grounding Bar
Main Fuse
Pullout
Line Lugs
Plug Fuse
Socket
Pullouts

Parts of a Breaker Load Center


Grounded Bar
(Neutral)
Main Lugs
Main Circuit
Breaker
Pole Spaces
Bus Bars

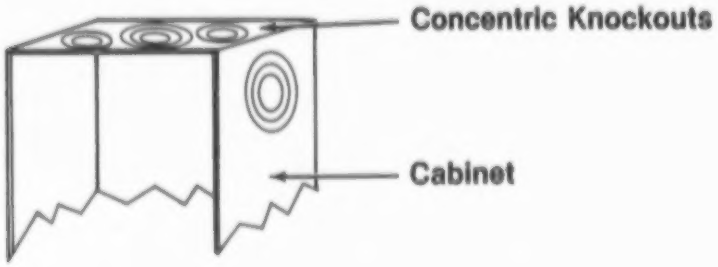
LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

INFORMATION SHEET

I. **Terms and definitions**

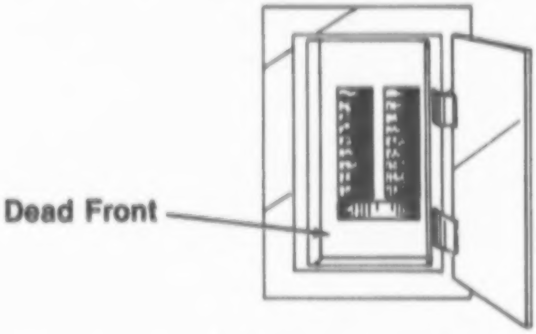
A. Cabinet — An enclosure designed either for surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung

B. Concentric knockout — Several removable metal rings that allow for entrance of various standard sizes of connectors into a cabinet



(NOTE: Standard concentric knockout sizes are 1/2 inch, 3/4 inch, 1 inch, 1 1/4 inch, 1 1/2 inch, 2 inch, and 2 1/2 inch.)

C. Dead front — Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment



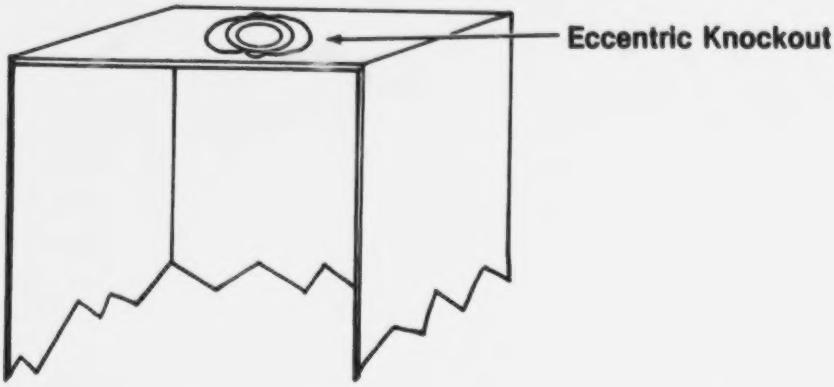
D. Disconnecting means -- A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

E. Dustproof — So constructed or protected that dust will not interfere with its successful operation

F. Dust-tight — So constructed that dust will not enter the enclosing case

INFORMATION SHEET

G. Eccentric knockout — Knockout that is removed in sections to form larger holes



H. NEMA (National Electrical Manufacturer's Association) — Organization responsible for the setting of specifications for the various classes of enclosures

I. NEMA Type 1 — General purpose enclosure for use indoors under usual service conditions

J. NEMA Type 2 — Driptight enclosure used indoors to exclude falling moisture and dirt

K. NEMA Type 3 — Weather resistant (weatherproof) and suitable for indoor and outdoor use; will exclude falling dirt, light liquid splashing, rain, snow, sleet, and windblown dust

(NOTE: Descriptors placed after the code number specify the suitable applications. A NEMA Type 3R is a common residential outdoor enclosure. The R stands for raintight and signifies that the enclosure will not exclude windblown dust.)

L. NEMA Type 4 — Watertight and dustproof enclosures suitable for areas where a great amount of splashing occurs, such as hose down area

M. NEMA Type 5 — Dust-tight enclosure not suitable for use around water

(NOTE: All NEMA Type 12 enclosures and JIC (Joint Industry Conference) enclosures are suitable for NEMA Type 5 applications.)

N. NEMA Type 12 — Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

O. Rainproof — So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus

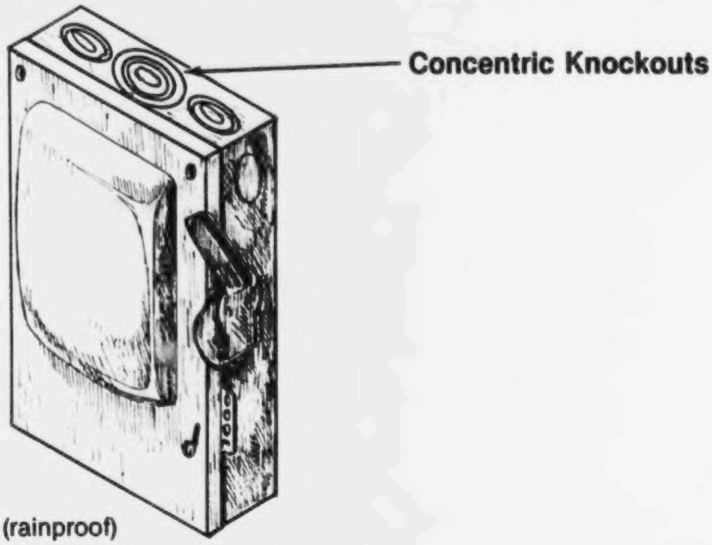
P. Raintight — So constructed or protected that exposure to a beating rain will not result in the entrance of water

INFORMATION SHEET

II. Types of safety switch enclosures

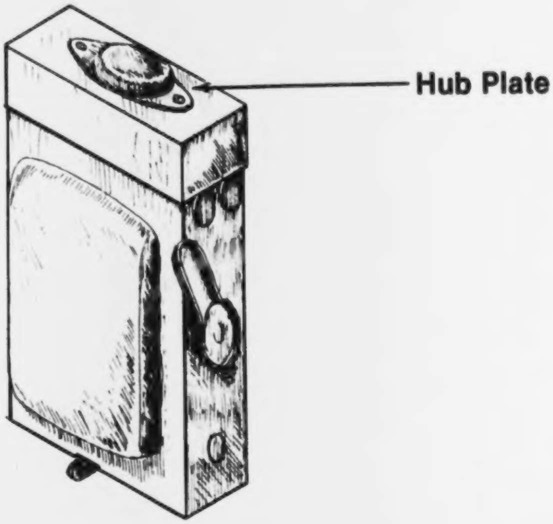
A. NEMA 1 (indoor)

(NOTE: NEMA 1 safety switch enclosures may be easily identified because of the presence of concentric knockout on the top of the enclosure.)



B. NEMA 3R (rainproof)

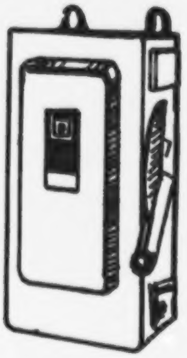
(NOTE: NEMA 3R safety switch enclosures may be easily identified by the presence of a hub plate on the top of the safety switch.)



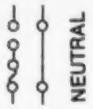
INFORMATION SHEET

C. NEMA 4X (water tight) (corrosion resistant)

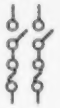
(NOTE: NEMA 4C enclosures are generally constructed of stainless steel.)



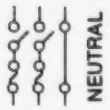
III. Safety switch system configurations



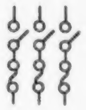
A. 2-wire
solid neutral (S/N)
1 blade, 1 fuse



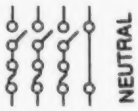
B. 2-wire
2 blades, 2 fuses



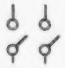
C. 3-wire S/N
2 blades, 2 fuses



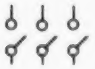
D. 3-pole fusible
solid neutral (S/N)



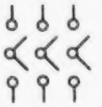
E. 4-wire S/N
2 blades, 2 fuses



F. 2-pole non-fusible
2 blades, 2 fuses



G. 3-pole non-fusible

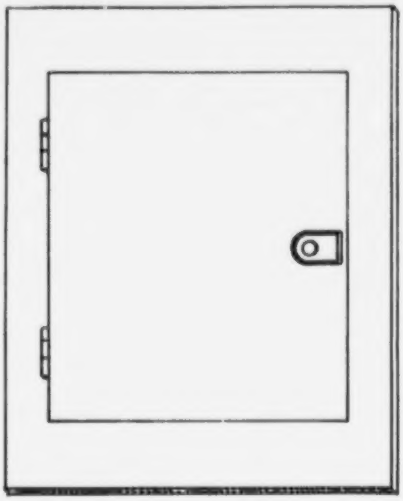


H. Double pole double throw

INFORMATION SHEET

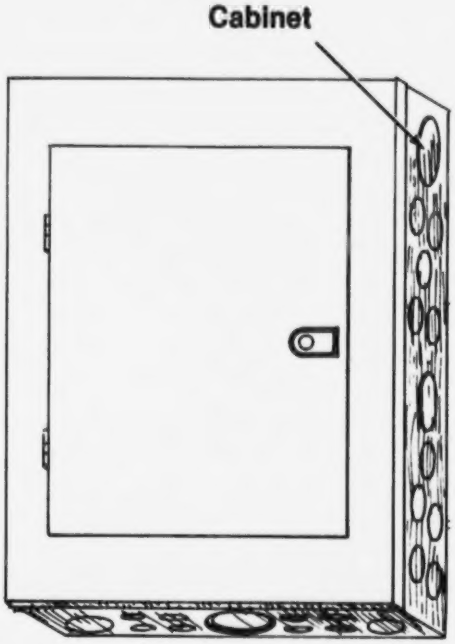
IV. Types of load centers and enclosures

A. Flush mount (NEMA 1)



B. Surface mount (generally NEMA 1)

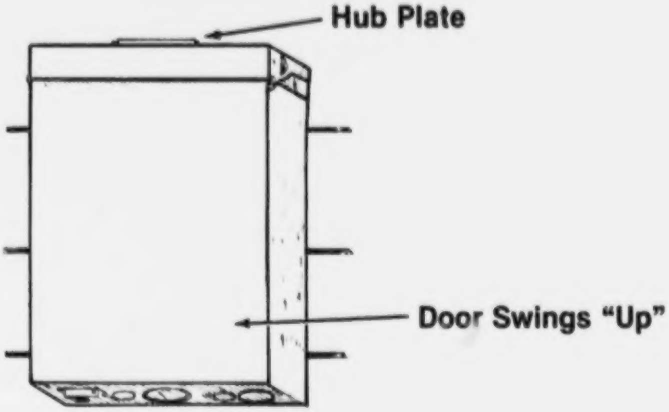
(NOTE: In most cases surface mount and flush mount load centers use the same cabinets; however, other cabinets may be ordered for special installations.)



INFORMATION SHEET

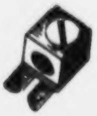
C. Exterior surface (NEMA 3R)

(NOTE: NEMA 3R load center enclosures are identified by the presence of a hub plate on the top.)

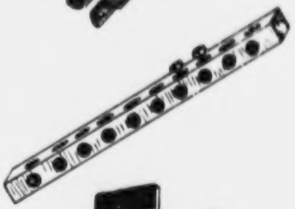


V. Load center accessories and their uses

A. Lug — Used for termination of conductors

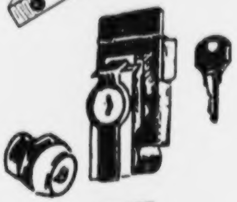


B. Grounded (neutral) bar — Used for termination of circuit grounded conductors

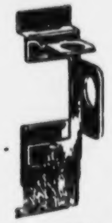


C. Grounding bar — Used for termination of equipment grounding conductors

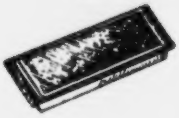
D. Flush locks — Used for locking of cabinet doors to allow entrance of only qualified personnel



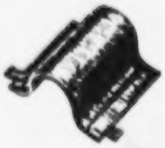
E. Padlock attachment — Used to lock breakers in the "off" or "on" position



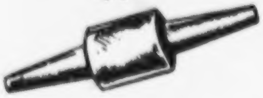
F. Closure plate — Used to fill empty breaker spaces where "breakouts" have been removed



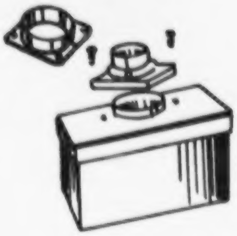
INFORMATION SHEET



G. Lock off — Used to lock breakers in the "off" position for equipment maintenance or servicing



H. Handle tie — Used to mechanically tie two or more breaker handles together to assure common tripping



I. Conduit hubs — Used to allow entrance of conduits to rainproof enclosures

VI. **Parts of a fusible load center**

A. Grounded bar (neutral)

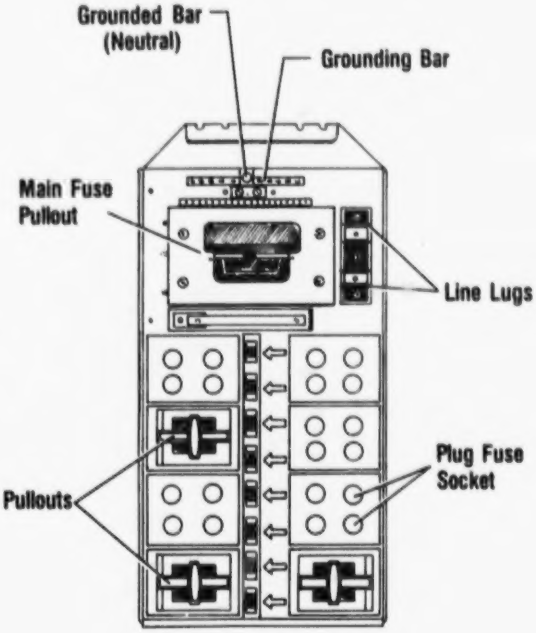
B. Grounding bar

C. Main fuse pullout

D. Line lugs

E. Plug fuse socket

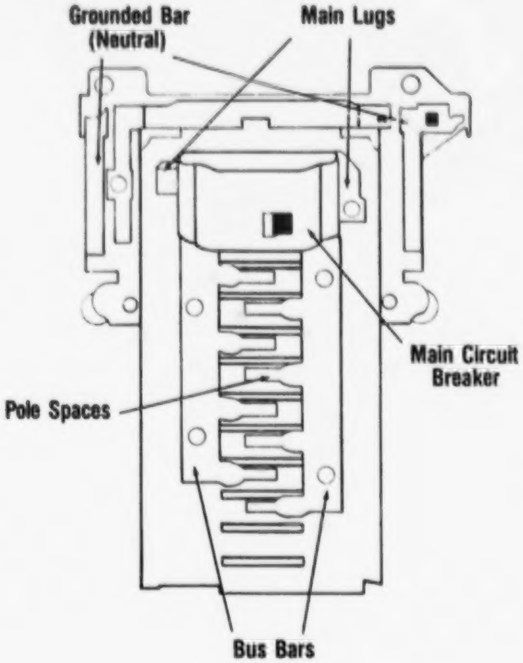
F. Pullouts


Grounded Bar
(Neutral)
Grounding Bar
Main Fuse
Pullout
Line Lugs
Plug Fuse
Socket
Pullouts

INFORMATION SHEET

VII. **Parts of a breaker load center**

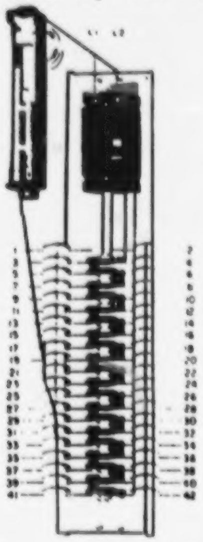
- A. Main breaker line lugs
- B. Grounded bar (neutral)
- C. Main circuit breaker
- D. Bus bars
- E. Pole spaces


Grounded Bar (Neutral)
Main Lugs
Main Circuit Breaker
Pole Spaces
Bus Bars

772

INFORMATION SHEET

VIII. Common panel bus configurations


L1 L2
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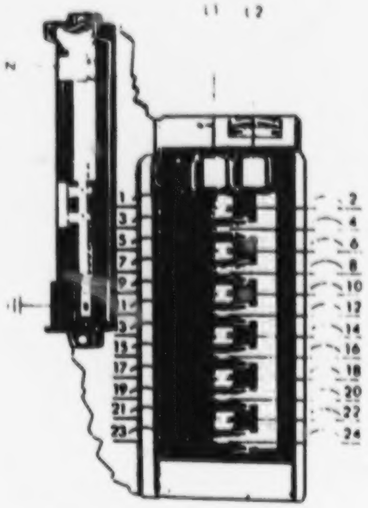
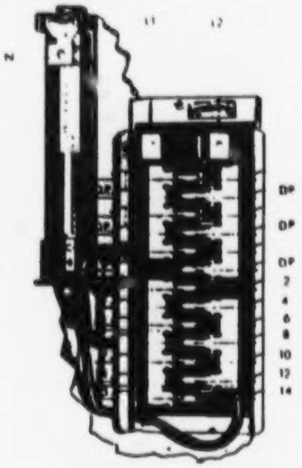
42

A. Main breaker single phase

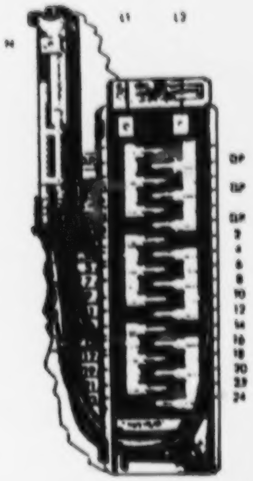

L1 L2
N
1
3
5
7
9
11
13
15
17
19
21
23
2
4
6
8
10
12
14
16
18
20
22
24

B. Main lug only (MLO) single phase

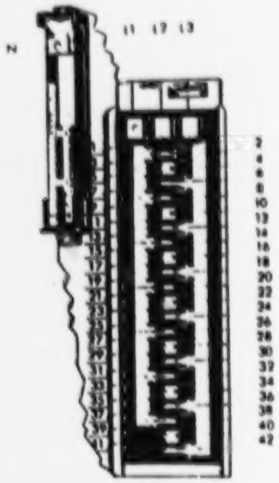

L1 L2
N
DP
DP
DP
2
4
6
8
10
12
14

C. Split bus single phase

INFORMATION SHEET


N
L1
L2
DP
DP
DP
2
4
6
8
10
12
14
16
18
20
22
24

D. Double split bus single phase


N
L1
L2
L3
2
4
6
8
10
12
14
16
18
20
22
24
26
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30
32
34
36
38
40
42

E. Three-phase MLO

IX. **Safety rules for working around load centers and safety switches**

A. Don't tamper with or alter equipment.

B. Install for intended purpose.

C. Install according to NEC.

D. Don't hold extra tools in your hand during installation or maintenance.

E. Stand to the side of a disconnect before energizing it.

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

ASSIGNMENT SHEET #1 — USING THE NEC, ANSWER QUESTIONS RELATED TO LOAD CENTERS

NAME ______________________________ SCORE ____________

(NOTE: A load center may be considered a switchboard, panelboard, or distribution board.)

Directions: Answer the following questions which are related to load centers. Use the National Electrical Code and state the code reference number.

A. Is it necessary to have a dedicated room for the location of load centers?

____

Code Reference ____________

B. What code articles reference this type of equipment?

____

Code Reference ____________

C. What is the minimum wire bending space for a load center with one 2/0 conductor per terminal?

____

Code Reference ____________

____

D. What is the maximum number of overcurrent devices allowed in any one panelboard?

____

Code Reference ____________

E. May a NEMA 1 load center enclosure be installed in a wet location?

____

Code Reference ____________

____

ASSIGNMENT SHEET #1

F. May the grounding bar of a load center, serving as a subpanel, be connected to the neutral bar?

Code Reference

G. Is a deadfront required on a load center in a residential dwelling?

Code Reference

H. What is the minimum front working space required for a load center of less than 600 volts?

Code Reference

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

ANSWERS TO ASSIGNMENT SHEET #1

A.	No	384-4 (FPN)
B.	240, 250, 370, 380, 500 through 517	384-2
C.	6 inches	384-3(g), 373-6(b), Table 373-6(b)
D.	42	384-15
E.	No	384-17, 373-2
F.	No	384-27
G.	Yes	384-18
H.	3 feet	384-8, 110-16

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

JOB SHEET #1 — INSTALL A SAFETY SWITCH

A. Equipment and materials needed

1. General-duty safety switch (indoor or raintight, three-pole, four-wire, three-fuse switch, 250-volt, 60-ampere rating)
2. Pouch tools
3. Piece of #6 insulated wire, 10 feet long
4. 6 #10 sheet metal screws, ¾ inch long
5. Backboard and mounting screws
6. 3 FRNR fuses, 60 amperes
7. Level
8. 2 EMT conduit connectors, 1-inch diameter

B. Procedure

1. Determine exact installation location.
2. Install a mounting screw for the top mounting hole.
3. Hang switch box on the screw.

   (NOTE: The hole in the upper middle back of housing should slip over the screw head.)
4. Level the box.
5. Locate holes for the remaining two mounting screws.
6. Install the lower two mounting screws.

   (NOTE: Be sure that box is level.)
7. Open 1-inch knockout holes in top and bottom of switch housing.
8. Install a 1-inch EMT connector in each knockout hole.
9. Cut six 12-inch lengths of #6 wire.

JOB SHEET #1

10. Strip back one end of each piece of wire about $^5/_8$ inch.

11. Install three #6 wires through the 1-inch connector in the top of the switch housing, and connect to line terminals L1, L2, and L3.

    (NOTE: Install the wires neatly, being careful not to allow the wires to rub against any metal edge.)

12. Firmly tighten terminals L1, L2, and L3.

    (NOTE: Check manufacturer's torque specifications.)

    (CAUTION: Loose connections are a chief cause of electrical problems.)

13. Install three pieces of #6 wire through the 1-inch connector in the bottom of the switch housing, and connect to load terminals T1, T2, and T3.

    (NOTE: Install wires neatly, being careful not to allow the wires to rub against any metal edge.)

14. Firmly tighten terminals T1, T2, and T3.

    (NOTE: Check manufacturer's torque specifications.)

15. Determine length of ground wire by measuring from top of box to ground terminal.

16. Cut a piece of #6 wire to the measured length.

17. Strip back the lower end of the ground wire; install in the ground terminal and tighten.

18. Install ground wire through bottom hole in switch housing.

19. Form the ground wire neatly so that it will not touch any moving part of the switch.

20. Strip back upper end of ground wire; install ground wire in switch terminal and tighten.

21. Insert the three 60-amp fuses into the fuse clips.

    (NOTE: Fuse clips must fit tightly on each fuse. Have instructor evaluate your work. If installation is satisfactory, it may be used for completing Job Sheet #2.)

22. Clean work area; put away all equipment and materials.

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

JOB SHEET #2 — WIRE A LOAD CENTER OR BREAKER PANEL

A. Equipment and materials needed

1. Single-phase load center, 100 amperes
2. 2 two-pole breakers, 30 amperes
3. 2 single-pole breakers, 30 amperes
4. 8 single-pole breakers, 20 amperes
5. Studs or backboard for mounting panel
6. 4 #10 sheet-metal mounting screws, ¾ inch long
7. 2 pieces of #2 insulated copper wire, 30 inches each
8. Piece of #2 insulated copper wire, 60 inches long
9. 7 pieces of #10 insulated wire, 5 feet each (color other than green or white)
10. 8 pieces of #12 insulated wire, 6 feet each (color other than green or white)
11. 8 pieces of green #12 insulated wire, 6 feet each
12. 8 pieces of white #12 insulated wire, 6 feet each
13. 4 pieces of green #10 insulated wire, 6 feet each

    (NOTE: Length of ground wire may vary depending on location of neutral ground bar. Use good judgment in cutting wire lengths.)

14. Pouch tools
15. White or gray phasing tape
16. Compression-type EMT connector, 2-inch diameter
17. 12 compression-type EMT connectors, ½-inch diameter
18. Compression-type EMT connector, ¾-inch diameter
19. Breaker index sheet
20. Piece of #4 bare wire 3 feet long for use as a grounding electrode conductor

JOB SHEET #2

B. Procedure

1. Before mounting panel, open twelve ½-inch knockout holes, one ¾-inch knockout hole, and one ¼-inch knockout hole for EMT conduit.

   (NOTE: The 1 ¼-inch knockout hole will generally be located in the center of the top of the panel. The ½-inch and ¾-inch knockouts may be located in the top or bottom, or both top and bottom.)

2. Install the ½-inch and ¾-inch EMT connectors; tighten snugly.

3. Install the 2-inch EMT connector; tighten snugly.

4. Mount panelboard in designated location.

5. Connect one end of the #4 bare ground wire to the ground bar, allowing other end to hang from bottom of panel.

   (NOTE: Under actual installation, the lower end of the ground wire would terminate at the grounding electrode.)

6. Strip back one end of each piece of insulated wire approximately ⅝ to ¾ inch.

7. Install one piece of #2 wire through the 1 ¼-inch connector to the neutral bar connector; arrange the wire neatly to lay in back corner of the panel; then insert wire in neutral bar terminal and tighten snugly.

   (NOTE: The neutral conductor should lay in the back corner of the panel to leave adequate room for the other wires and breakers. It should also be identified by white or gray tape.)

8. Install the remaining 2 wires through the 2-inch connector, and insert wires in the main breaker connectors.

   (NOTE: Arrange wires neatly, allowing room for the branch-circuit conductors.)

9. Plug the two-pole breakers into the panel bus, one breaker on the right, the other on the left at the top positions.

10. Plug the two single pole 30 amp breakers into the panel bus, one breaker on the left, the other on the right in the top positions.

11. Plug the eight single-pole breakers into the panel bus, four breakers on the left, and four on the right in the remaining positions.

JOB SHEET #2

12. Install remaining wires.

    a. For the two-pole breakers, insert two #10 colored wires (other than green or white) and one #10 green wire through the ¾-inch connector.

       (NOTE: Extend all wires into the panel far enough to reach the neutral or ground bar, especially the green wire after arranging it in the back corner of panel down to ground bar.)

    b. For the single-pole 30A breakers, insert two #10 colored and one #10 green wire for each breaker.

    c. For the single-pole breakers, insert one #12 colored, one #12 white for neutral, and one #12 green wire for each breaker.

13. Tag or mark by number each group of wires that goes to a specific breaker.

14. Fold back out of the way all branch circuit wires inside the panel to provide clear working space inside panel.

15. Trim out panelboard.

    a. Work the green wires one at a time, arranging them against back of panel in corners and making right angle bends to the ground bar terminals.

    b. Cut, strip, and insert wires into terminals; tighten snugly.

       (NOTE: This method places this group of wires in the back of the panel, out of the way of neutral and circuit wires; also, it gives the technician an organized procedure for doing the work neatly.)

    c. Work the white neutral wires one at a time, laying the wires near the green wires in the back spaces and corners of the panel and making bends to the neutral or ground bar.

    d. Cut, strip, and insert wires into terminals; tighten snugly.

    e. Work the colored circuit wires.

       1) Work the #10 wires one at a time to the left two-pole breaker, forming the wire to lay neatly toward the back and side of panel; make right-angle bends to bring wire horizontally toward proper breaker terminal; make additional right-angle bends to bring wires outward and then into breaker.

          (NOTE: This procedure makes it easy to trace wires, provides enough wire length to pull out and check loads with a clamp-on ammeter, and produces a neat, professional-looking job.)

JOB SHEET #2

2) Work the #10 wires to the right two-pole breaker, using the procedure outlined in step 1.

3) Work the wires to the single-pole 30 amp breakers, using the procedure outlined in step e1.

4) Work the single-pole circuit wires, making neat bends and using the same procedure outlined in step e1.

f. Double-check to make sure that all connections make good contact and are tightened to manufacturer's torque specifications.

(NOTE: Have instructor evaluate your work.)

16. Carefully dismantle the assembly and store parts in proper places.

17. Clean work area and put away all equipment and materials.

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

JOB SHEET #3 — WIRE A RECEPTACLE CIRCUIT TO A LOAD CENTER

A. Equipment and materials needed

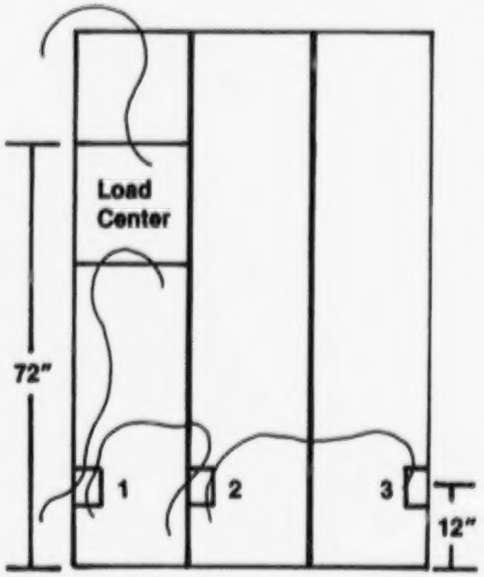
1. Pouch tools
2. ½" drill motor
3. ⅞" slip auger bit
4. Romex staples
5. 15' of 12/2 with ground NMB
6. 3 plastic 1 gauge nail up device boxes
7. 4' 10/3 with ground
8. 3 15 amp 125 volt duplex receptacles
9. 2 or 4 circuit load center
10. 1 - 20 amp single-pole breaker
11. 2 - ½" Romex connectors
12. 4 - #10×1 sheet metal screws

B. Procedure

1. Mark and lay out boxes according to drawing. (Figure 1)

JOB SHEET #3

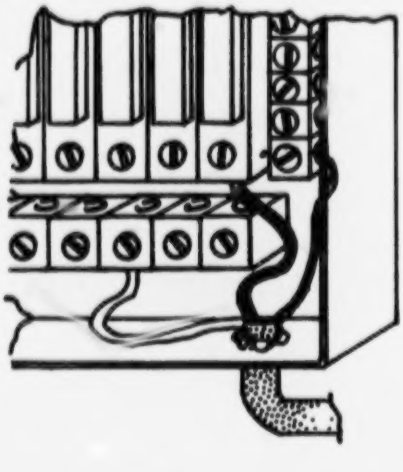
FIGURE 1



(NOTE: Be sure to check the NEC for installation of NM cable.)

2. Mount device boxes for ½ inch Sheetrock.
3. Mount load center for flush installation (½ inch Sheetrock).
4. Drill studs according to cable layout and NEC.
5. Route cable through studs and support properly.
6. Install Romex connector in bottom of load center and install cable. (Figure 2)

FIGURE 2



JOB SHEET #3

7. Strip sheath from cables in device boxes.

   (NOTE: Be sure at least 6 inches of conductor leaves the face of the box.)

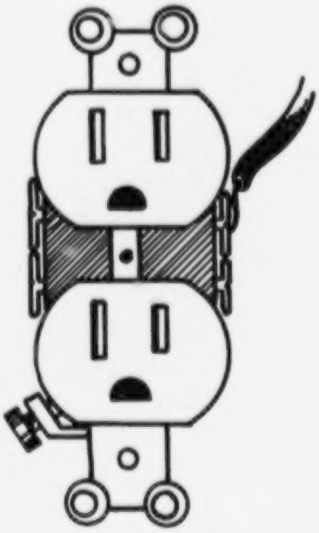
8. In boxes 1 and 2, twist grounds together and install a green wire nut, leaving enough pigtail to terminate on receptacle grounding terminal.

9. Strip ½" inch of insulation from neutral (white) conductors and twist in a 6-inch pigtail. Install a red wire nut over joint.

10. Terminate all conductors according to instructor's demonstration. (Figure 3)

    (NOTE: Methods may vary due to local codes.)

FIGURE 3



White Neutral Conductor to White or Silver Terminal

Black Conductor to Brass or Dark Terminal

Grounding Conductor to Green or Hex Headed Terminal

11. Install Romex connector in top of load center and terminate the 10/3 with ground as the feeder conductors.

12. Double check to make sure all terminations are tight.

    (NOTE: Have instructor evaluate your work.)

13. Carefully dismantle the assembly and store parts in proper places.

14. Clean work area and put away all equipment and materials.

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

PRACTICAL TEST
JOB SHEET #1 — INSTALL A SAFETY SWITCH

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Hung safety switch securely.	______	______
3. Hung safety switch level.	______	______
4. Stripped wires proper length.	______	______
5. Installed wires neatly.	______	______
6. Tightened all terminations adequately.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

4 3 2 1

Hung safety switch level

4 3 2 1

Tight termination

4 3 2 1

Workmanship

4 3 2 1

Compliance to NEC

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

PRACTICAL TEST
JOB SHEET #2 — WIRE A LOAD CENTER OR BREAKER PANEL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted panel securely.	______	______
3. Mounted panel level.	______	______
4. Installed breakers properly.	______	______
5. Terminated feeder conductors properly.	______	______
6. Terminated branch circuit conductors properly.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Secure mounting	4	3	2	1
Panel level	4	3	2	1
Termination tight	4	3	2	1
Conductors to correct breaker	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

BW-877

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

PRACTICAL TEST
JOB SHEET #3 — WIRE A RECEPTACLE CIRCUIT TO A LOAD CENTER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Proper layout and marking.	______	______
3.	Mounted device boxes properly.	______	______
4.	Mounted load center properly.	______	______
5.	Drilled holes properly.	______	______
6.	Routed cable properly.	______	______
7.	Supported cable properly.	______	______
8.	Proper makeup.	______	______
9.	Proper termination.	______	______
10.	Checked in/put away tools and materials.	______	______
11.	Cleaned the work area.	______	______
12.	Used proper tools correctly.	______	______
13.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
14.	Practiced safety rules throughout procedure.	______	______
15.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Proper placement and mounting	4	3	2	1
Proper cable routing and support	4	3	2	1
Proper makeup	4	3	2	1
Proper terminations	4	3	2	1
Holes drilled in approximate center	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

TEST

NAME ________________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

______a. Organization responsible for the setting of specifications for the various classes of enclosures

______b. General purpose enclosure for use indoors under usual service conditions

______c. Driptight enclosure used indoors to exclude falling moisture and dirt

______d. Weather resistant (weatherproof) and suitable for indoor or outdoor use; will exclude falling dirt, light liquid splashing, rain, snow, sleet, and windblown dust

______e. Watertight and dustproof enclosures suitable for areas where a great amount of splashing occurs, such as hose down areas

______f. Dust-tight enclosures are not suitable for use around water

______g. Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

______h. An enclosure designed either for surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung

______i. A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

______j. So constructed or protected that dust will not interfere with its successful operation

______k. So constructed that dust will not enter the enclosing case

1. Cabinet
2. Concentric knockout
3. Dead front
4. Disconnecting means
5. Dustproof
6. Dust-tight
7. Eccentric knockout
8. NEMA (National Electrical Manufacturer's Association)
9. NEMA Type 1
10. NEMA Type 2
11. NEMA Type 3
12. NEMA Type 4
13. NEMA Type 5
14. NEMA Type 12
15. Rainproof
16. Raintight

TEST

_____l. So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus

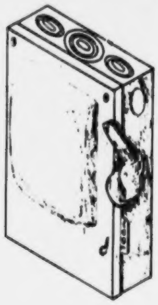
_____m. So constructed or protected that exposure to a beating rain will not result in the entrance of water

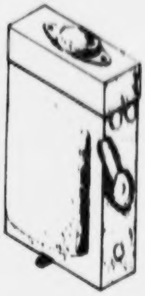
_____n. Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment

_____o. Several removable metal rings that allow for the entrance of various standard sizes of connectors into a cabinet

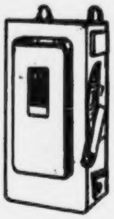
_____p. Knockout that is removed in sections to form larger holes

2. Identify the following types of safety switch enclosures.





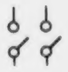
a. ______________________ b. ______________________

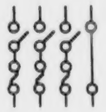


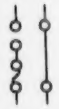
c. ______________________

TEST

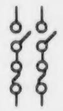
3. Identify the safety switch system configurations below.

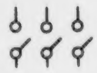


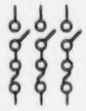




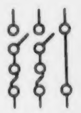
a. ____________ b. ____________ c. ____________

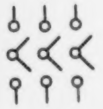






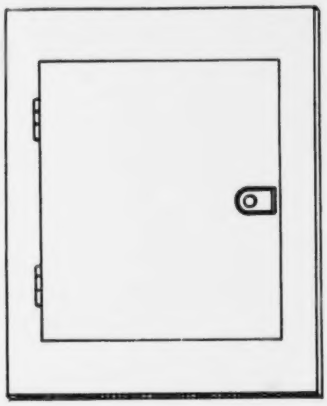
d. ____________ e. ____________ f. ____________

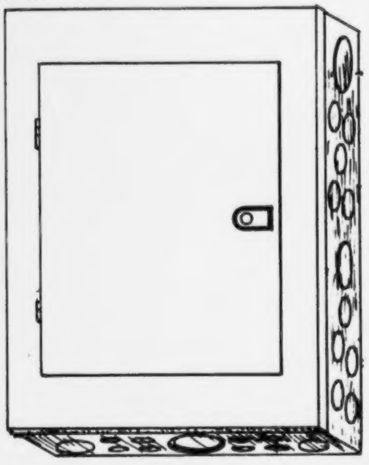




g. ____________ h. ____________

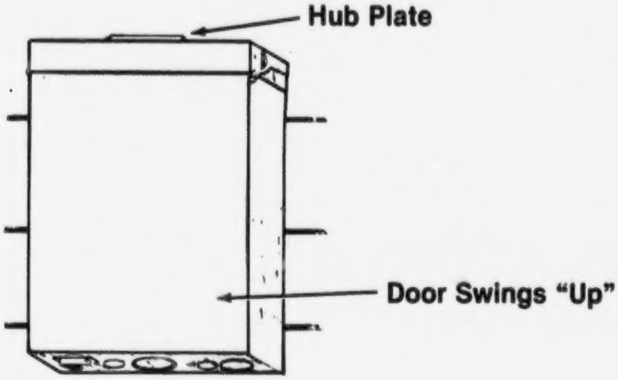
4. Identify the types of load centers and enclosures below.





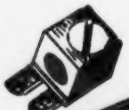
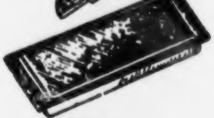
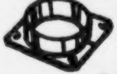
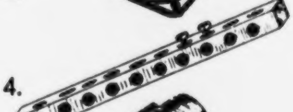
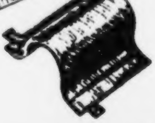
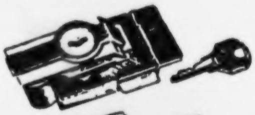
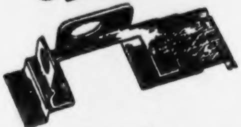
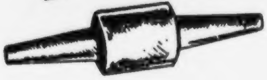
a. ____________ b. ____________

TEST



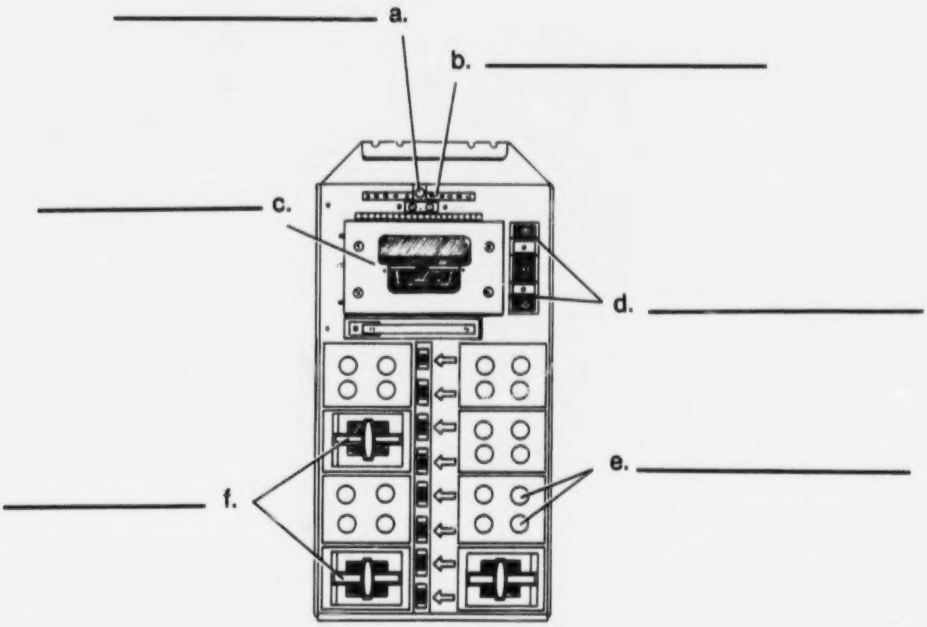
c. ______________________________

5. Match common load center accessories on the right with their uses.

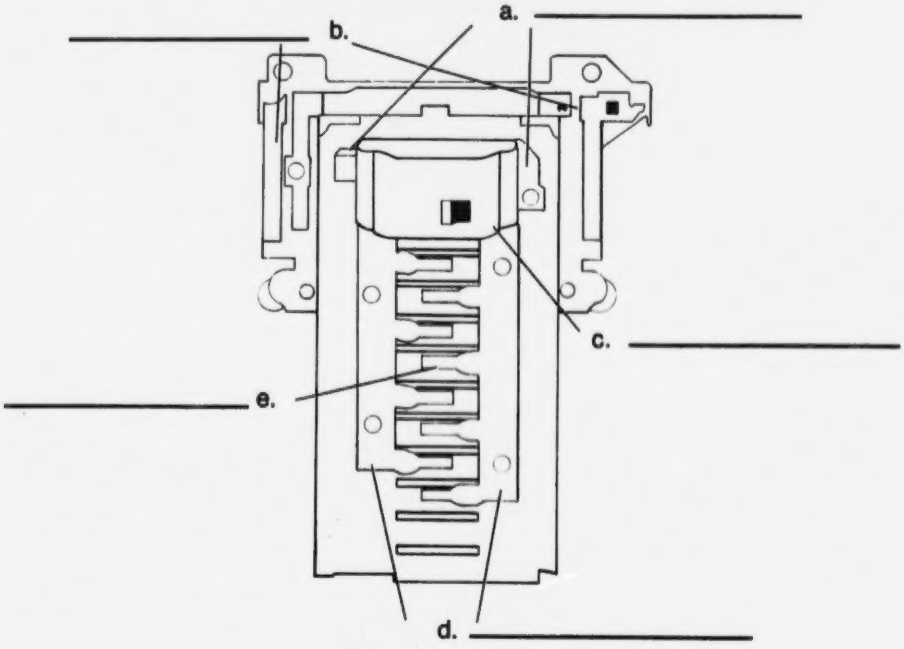
_____a. Used for termination of conductors	1.	
_____b. Used for termination of circuit grounded conductors	2.	
_____c. Used for termination of equipment grounding conductors	3.	
_____d. Used for locking of cabinet doors to allow entrance of only qualified personnel	4.	
_____e. Used to lock breakers in the "off" or "on" position	5.	
_____f. Used to fill empty breaker spaces where "breakouts" have been removed	6.	
_____g. Used to lock breakers in the "off" position for equipment maintenance or servicing	7.	
_____h. Used to mechanically tie two or more breaker handles together to assure common tripping	8.	
_____i. Used to allow entrance of conduits to rainproof enclosures		

TEST

6. Label the parts of a fusible load center.

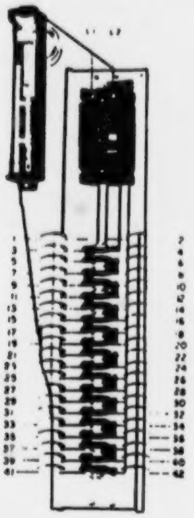


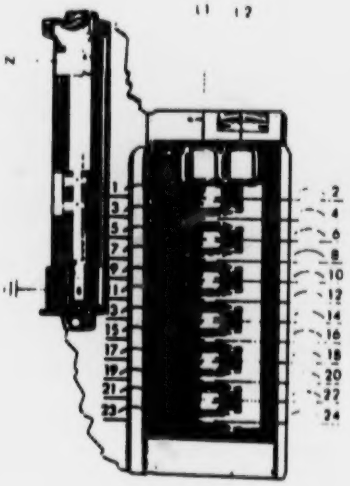
7. Label the parts of a breaker load center.

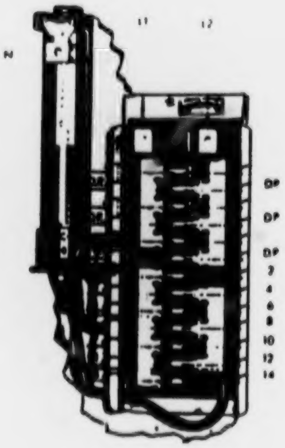


TEST

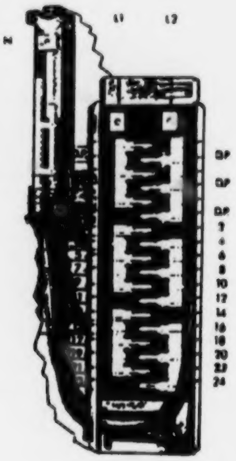
8. Identify common panel interior configurations shown below.

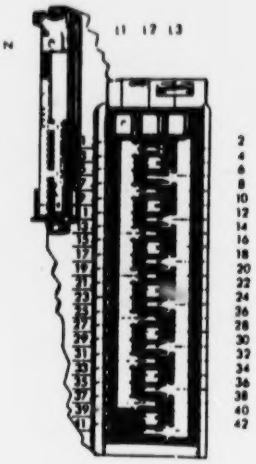



L1 L2
N
1 3 5 7 9 11 13 15 17 19 21 23
2 4 6 8 10 12 14 16 18 20 22 24


L1 L2
N
DP
DP
DP
2 4 6 8 10 12 14

a. ______________________ b. ______________________ c. ______________________


L1 L2
N
DP
DP
DP
2 4 6 8 10 12 14 16 18 20 22 24


L1 L2 L3
N
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42

d. ______________________ e. ______________________

TEST

9. Select true statements concerning safety rules for working around load centers and safety switches by placing an "X" in the blanks preceding the true statements.

    _____a. Don't tamper with or alter equipment.

    _____b. Install for intended purpose.

    _____c. Install according to NEC.

    _____d. Don't hold extra tools in your hand during installation or maintenance.

    _____e. Stand in front of a disconnect before energizing it.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

10. Using the NEC, answer questions related to load centers. (Assignment Sheet #1)

11. Demonstrate the ability to:

    a. Install a safety switch. (Job Sheet #1)

    b. Wire a load center. (Job Sheet #2)

    c. Wire a receptacle circuit to a low center. (Job Sheet #3)

LOAD CENTERS AND SAFETY SWITCHES
UNIT XV

ANSWERS TO TEST

1. a. 8
   b. 9
   c. 10
   d. 11
   e. 12
   f. 13
   g. 14
   h. 1
   i. 4
   j. 5
   k. 6
   l. 15
   m. 16
   n. 3
   o. 2
   p. 7

2. a. NEMA 1 (indoor)
   b. NEMA 3R (rainproof)
   c. NEMA 4X (watertight, corrosion resistant)

3. a. 2-pole non-fusible
   b. 4 wire S/N 1 blade, 3 fuse
   c. 2 wire S/N 1 blade, 1 fuse
   d. 2 wire 2 blade, 2 fuse
   e. 3 pole non-fusible
   f. 3 pole fusible
   g. 3 wire S/N 2 blades, 2 fuses
   h. Double pole double throw

4. a. Flush mount (NEMA 1)
   b. Surface mount (generally NEMA 1)
   c. Exterior surface (NEMA 3R)

5. a. 1
   b. 4
   c. 4
   d. 6
   e. 7
   f. 2
   g. 5
   h. 8
   i. 3

6. a. Grounded (neutral) bar
   b. Grounding bar
   c. Main fuse pullout
   d. Line lugs
   e. Plug fuse sockets
   f. Pull outs

7. a. Main breaker line lugs
   b. Grounded (neutral) bar
   c. Main breaker
   d. Bus bars
   e. Pole spaces

ANSWERS TO TEST

8. a. Main breaker single phase
   b. Main lug only (MLO) single phase
   c. Split bus single phase
   d. Double split bus single phase
   e. Three phase MLO

9. a, b, c, d

10. Evaluated to the satisfaction of the instructor

11. Performance skills evaluated to the satisfaction of the instructor

EXISTING STRUCTURES
UNIT XVI

UNIT OBJECTIVE

After completion of this unit, the student should be able to determine the number of conductors allowed in an existing conduit and install additional box locations and cable runs in existing structures. Competencies will be demonstrated by completing the assignment sheet, job sheets, and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to existing structures with their correct definitions.
2. Identify construction members common in existing structures.
3. List four common routes for new cable installations in existing structures.
4. Complete a list of possible methods for getting cable through or around construction members.
5. List five wall or ceiling compositions that may be found in an existing structure.
6. Complete statements concerning conditions for using the optional calculations for additional loads to existing installations.
7. List exceptions to the NEC requirements for support of flexible metal conduit.
8. Arrange in order the steps for determining the number of conductors allowed in a conduit, based on cross-sectional area.
9. Determine the number of conductors allowed to be added to an existing conduit. (Assignment Sheet #1)

OBJECTIVE SHEET

10. Demonstrate the ability to:

    a. Install a box with dry wall grips in a plasterboard wall. (Job Sheet #1)

    b. Secure a box with dry wall supports (box tins). (Job Sheet #2)

    c. Install a box in a lath and plaster wall. (Job Sheet #3)

    d. Install a box in a paneled wall. (Job Sheet #4)

    e. Install a box in a concrete block wall. (Job Sheet #5)

    f. Install a box in a brick wall. (Job Sheet #6)

    g. Install a box in a ceiling with an accessible attic. (Job Sheet #7)

    h. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind bare board. (Job Sheet #8)

    i. Install cable between an existing box and a newly installed box using an under floor crawl space. (Job Sheet #9)

    j. Install cable between an existing box and a newly installed box using attic space. (Job Sheet #10)

EXISTING STRUCTURES
UNIT XVI

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Coordinate an activity with the carpentry instructor or outside contractor to construct a trainer wall with necessary wall coverings for this unit.
2. Coordinate an activity with the masonry instructor or outside contractor to construct a trainer wall of both brick and concrete block.
3. Discuss fishing techniques in two story houses.
4. Take a field trip to a remodeled or old house with exposed construction members.
5. Visit a local electrical remodel job on a commercial building.
6. Have a local inspector speak to class about remodel work.
7. Discuss possible problems that can arise in cutting in boxes in existing walls.
8. Demonstrate knife scoring technique for cutting box opening in plasterboard.
9. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

J. Give test.

K. Evaluate test.

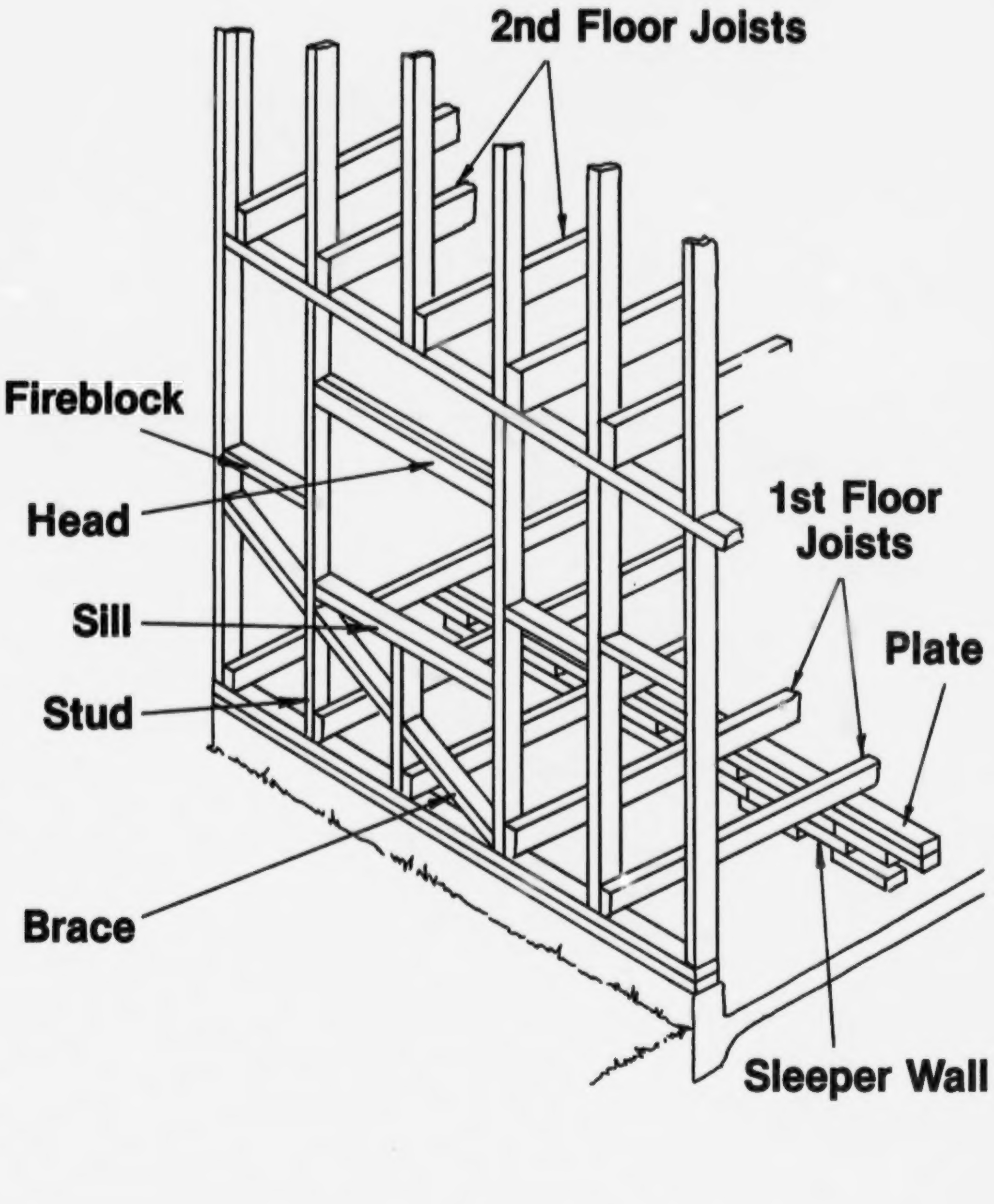
L. Reteach if necessary.

REFERENCE USED IN WRITING THIS UNIT

A. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

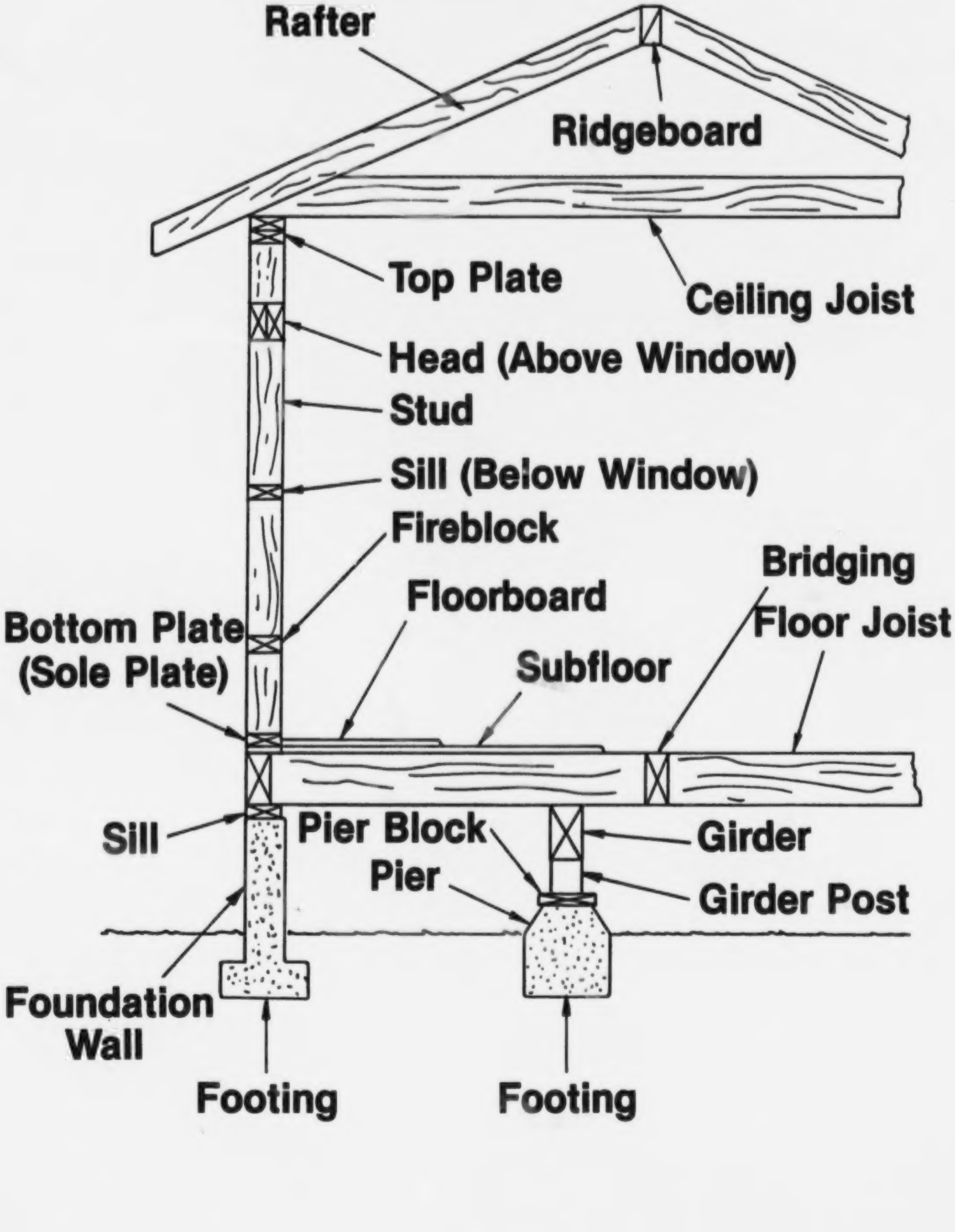
B. National Electrical Code, 1987. Quincy, MA: National Fire Protection Association, 1986.

Construction Members

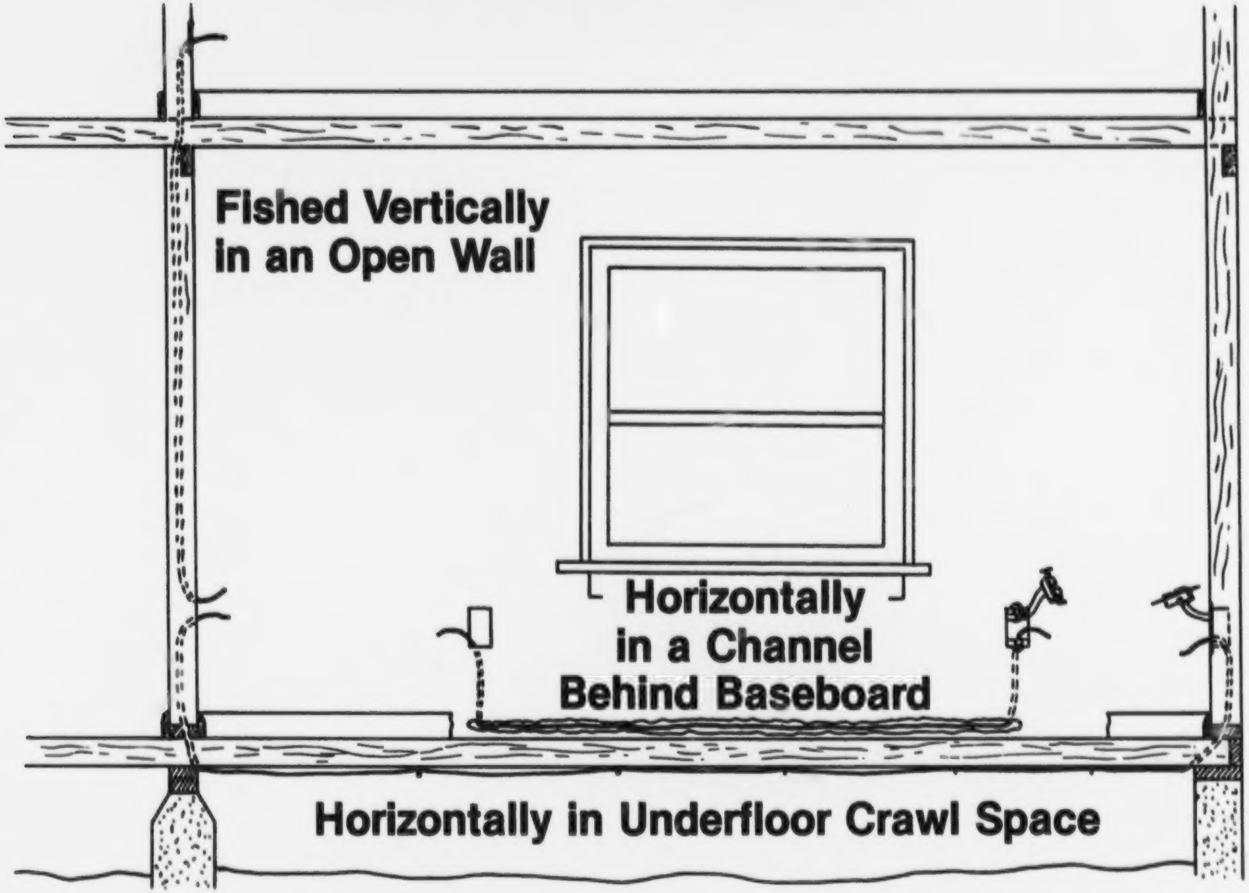

2nd Floor Joists
Fireblock
Head
Sill
Stud
Brace
1st Floor Joists
Plate
Sleeper Wall

806

Construction Members
(Continued)


Rafter
Ridgeboard
Top Plate
Ceiling Joist
Head (Above Window)
Stud
Sill (Below Window)
Fireblock
Bridging
Floorboard
Floor Joist
Bottom Plate (Sole Plate)
Subfloor
Sill
Pier Block
Girder
Pier
Girder Post
Foundation Wall
Footing
Footing

Common Routes For New Cable Installations



Fished Vertically in an Open Wall

Horizontally in a Channel Behind Baseboard

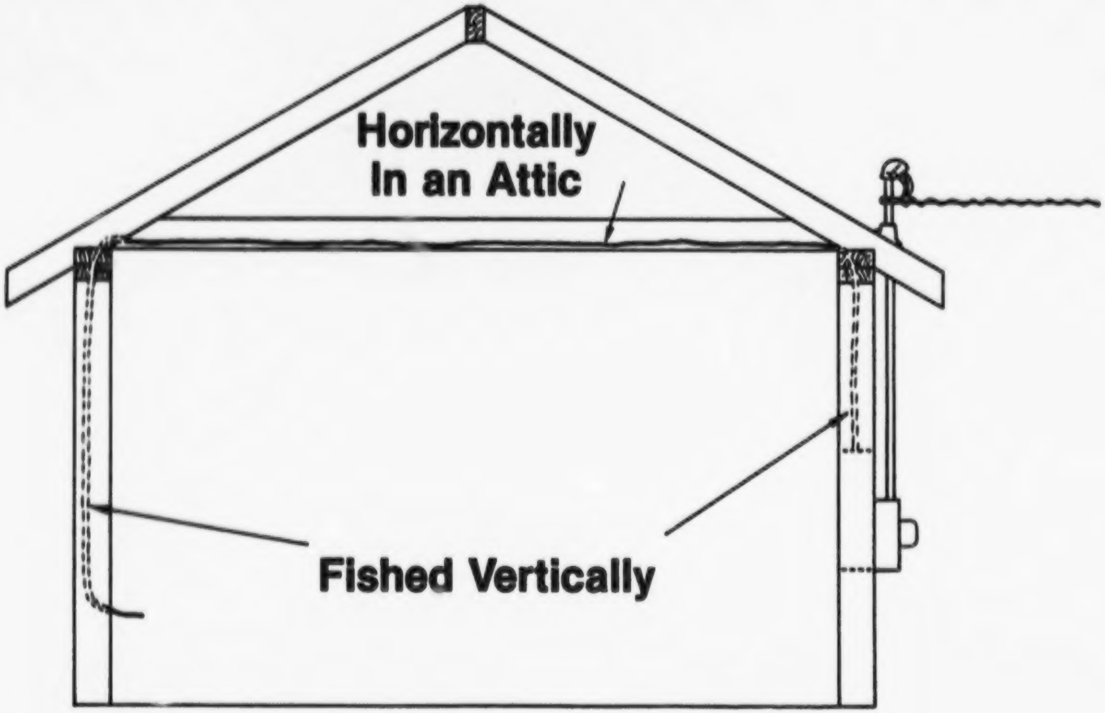
Horizontally in Underfloor Crawl Space

TM 3
Objective III

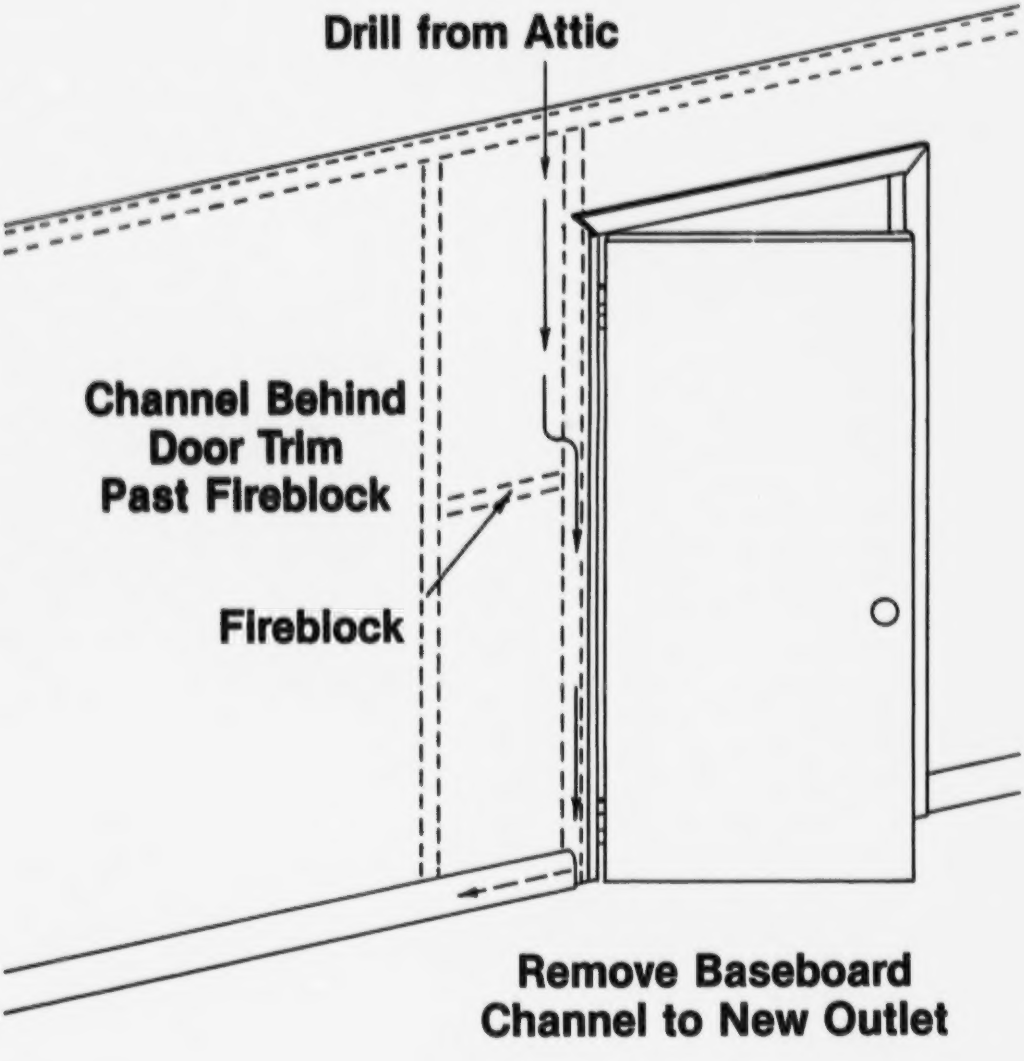
BW-897

Common Routes For New Cable Installations

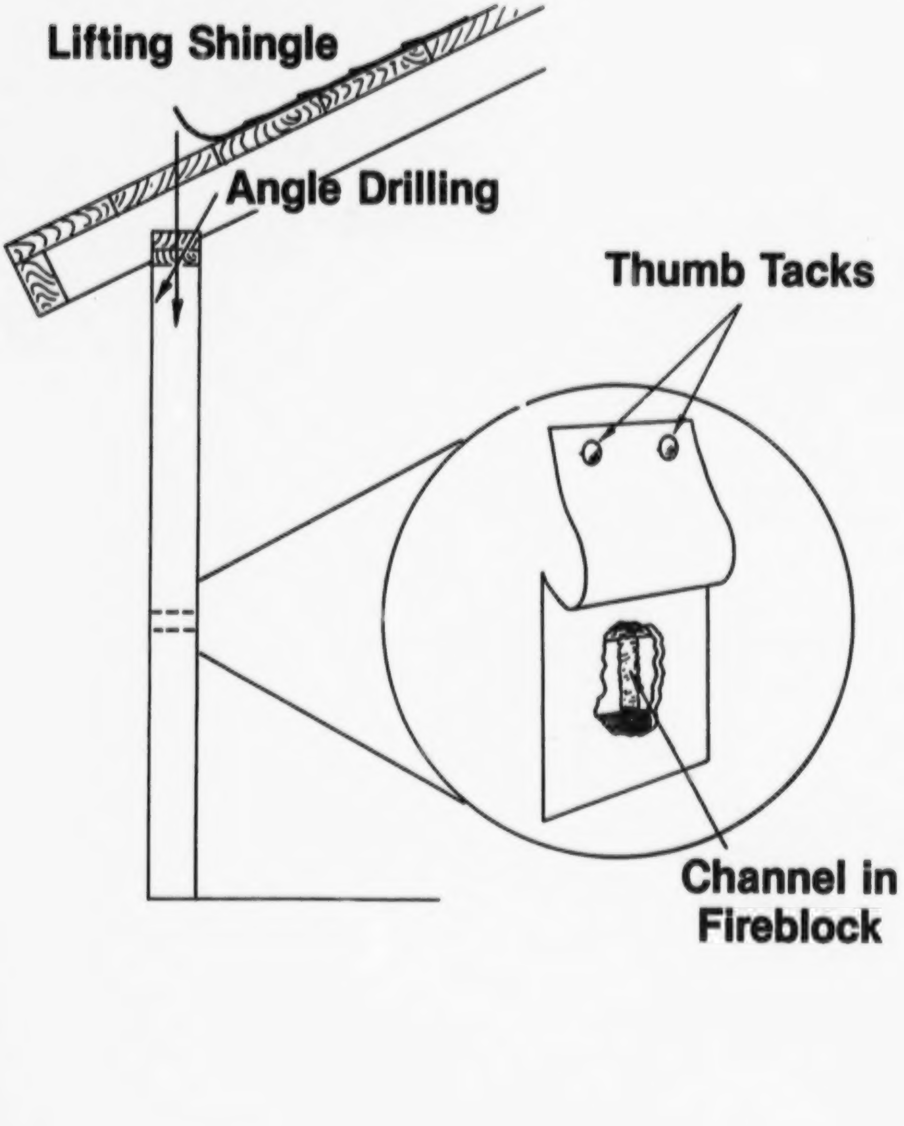
(Continued)


Horizontally In an Attic
Fished Vertically

Working Past Fireblocks


Drill from Attic
Channel Behind
Door Trim
Past Fireblock
Fireblock
Remove Baseboard
Channel to New Outlet

Working Past Fireblocks
(Continued)


Lifting Shingle
Angle Drilling
Thumb Tacks
Channel in Fireblock

EXISTING STRUCTURES
UNIT XVI

INFORMATION SHEET

I. **Terms and definitions**

A. Brick bat — Piece of a brick

B. Channel — Groove formed in materials

C. Cross sectional area — Area in square inches allowed in a conduit or tubing; area required for conductors in a conduit or tubing

D. Drop chain — Short length of small chain used to pull cable or flexible conduit through an enclosed space or wall cavity

E. Drop cloth — Cloth used to catch falling debris from cutting or chipping work

F. Fish — Establishing a connection between two points so a cable can be installed

G. Fish wire — Length of wire with a hook formed in one end to catch materials being installed in a space

H. Lath and plaster — Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

I. Pipe chase — Usually a vertical space between two floors, dedicated for the running of pipes and conduits between floors

J. Plasterboard (Sheetrock) — Flat sheets used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

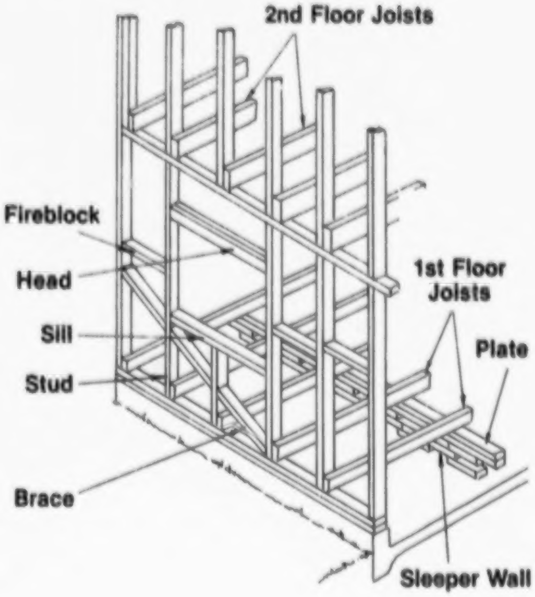
K. Stud finder — Compass type tool which uses a magnet to locate nails and thus indicate stud locations

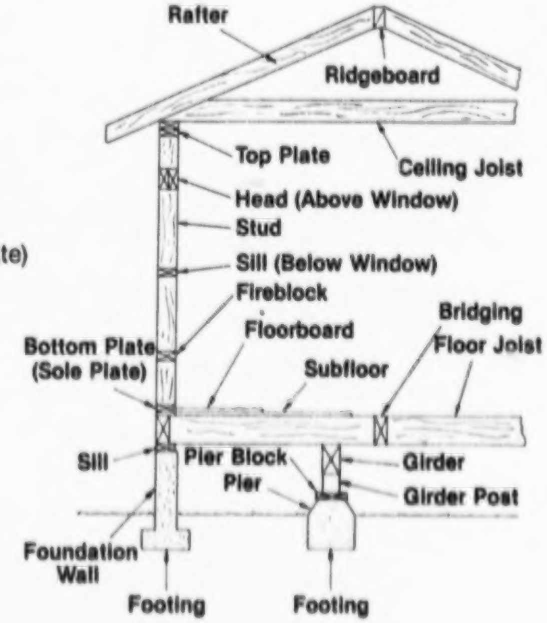
L. Underfloor crawl space — Working space underneath the house

INFORMATION SHEET

II. Construction members common in existing structures

A. Fire block
B. Header
C. Sill
D. First floor joists
E. Plate
F. Studs
G. Brace
H. Sleeper wall
I. Rafter
J. Ridge board
K. Top plate
L. Ceiling joists
M. Floor board
N. Bridging
O. Sub floor
P. Bottom plate (sole plate)
Q. Girder
R. Pier block
S. Girder post
T. Pier
U. Foundation wall
V. Footing


2nd Floor Joists
Fireblock
Head
Sill
Stud
Brace
1st Floor Joists
Plate
Sleeper Wall


Rafter
Ridgeboard
Top Plate
Ceiling Joist
Head (Above Window)
Stud
Sill (Below Window)
Fireblock
Floorboard
Bridging
Floor Joist
Bottom Plate (Sole Plate)
Subfloor
Sill
Pier Block
Girder
Pier
Girder Post
Foundation Wall
Footing
Footing

INFORMATION SHEET

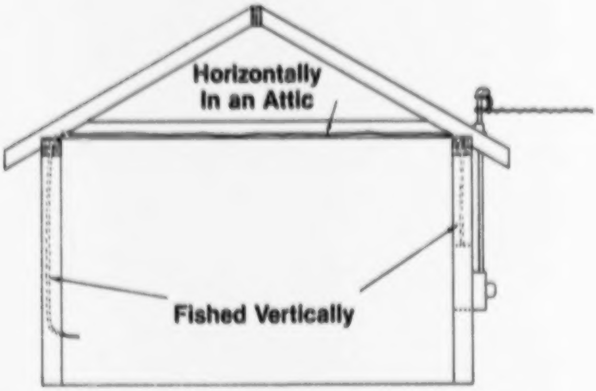
III. **Common routes for new cable installations in existing structures**

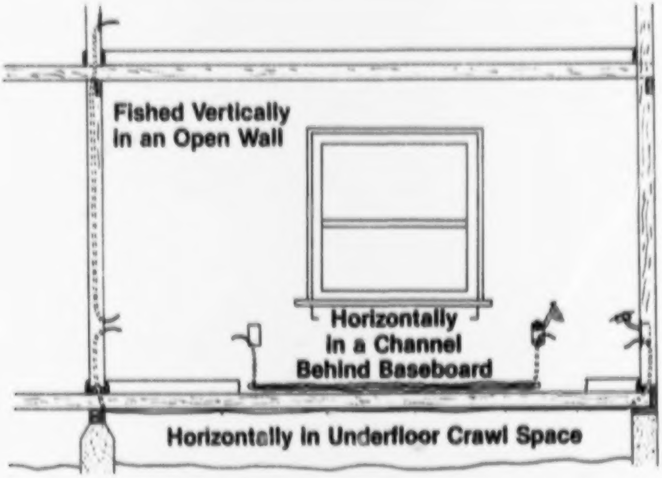
   A. Vertically in a wall

   B. Horizontally in a channel behind baseboard

   C. Horizontally in underfloor crawl space

   D. Horizontally in an attic


Horizontally
In an Attic
Fished Vertically


Fished Vertically
In an Open Wall
Horizontally
In a Channel
Behind Baseboard
Horizontally in Underfloor Crawl Space

INFORMATION SHEET

IV. **Possible methods for getting cable through or around construction members**

(NOTE: Good electricians can think their way around almost anything.)

A. Top plates

1. Straight drilling
2. Angle drilling
3. Lifting a shingle and drilling
4. Over top plate and back through insulation board inside eave

   (NOTE: Select the method which is easiest and causes the least structural boring or changing to make a safe professional installation.)

B. Bottom plates (sole plate)

1. Top drilling behind baseboard
2. Bottom drilling

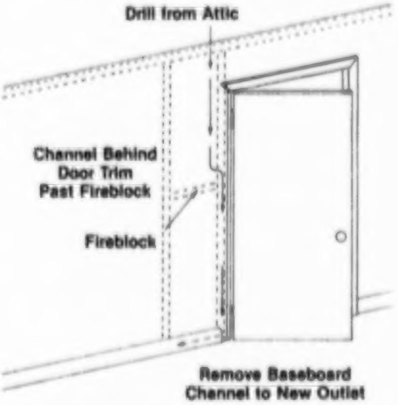
   (NOTE: This is the preferred method due to the time involved in removal and reinstallation of baseboard.)

C. Fire blocks

1. Lifting shingle and top drilling through block with extension

   (NOTE: This works if the fire block is fairly high in the wall.)

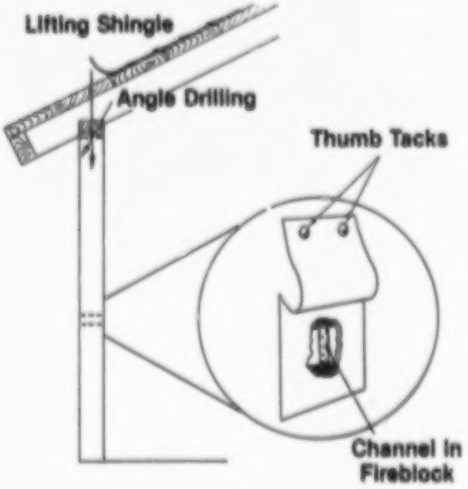
2. Top drilling with door trim and baseboard removal


Drill from Attic
Channel Behind Door Trim Past Fireblock
Fireblock
Remove Baseboard Channel to New Outlet

INFORMATION SHEET

3. Top drilling and channeling past

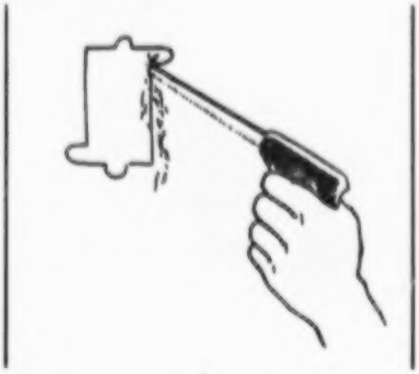
   (NOTE: Be sure and smooth out your work with spackling or joint compound before laying wallpaper back down.)


Lifting Shingle
Angle Drilling
Thumb Tacks
Channel In Fireblock

V. Wall or ceiling composition

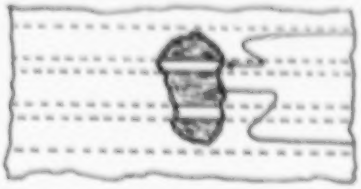
   A. Plasterboard

      (NOTE: This is commonly called Sheetrock and is used in the majority of the interior walls in new structures.)

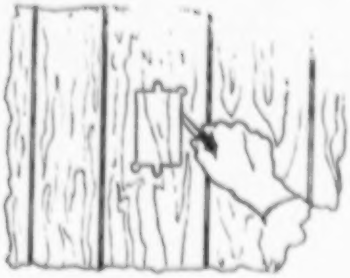


INFORMATION SHEET

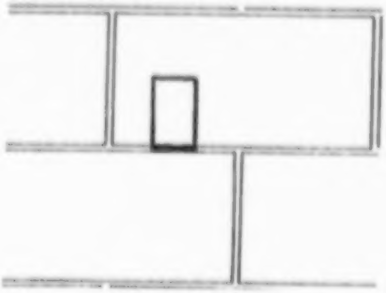
B. Lath or plaster



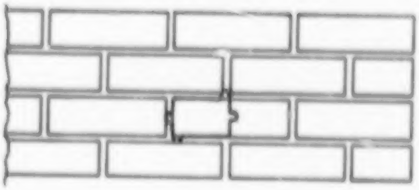
C. Paneling



D. Concrete block



E. Brick



INFORMATION SHEET

VI. Optional calculation for additional loads to existing installations

(NOTE: For the purpose of allowing additional loads to be connected to existing feeders and services, it shall be permitted to use the actual KVA demand figures to determine the existing load on a service or feeder when all the following conditions are met. Refer to NEC Article 230-35[1][2][3].)

A. The maximum demand data is available in KVA for a minimum of a one year period.

B. The existing demand at 125 percent plus the new load does not exceed the ampacity of the feeders or rating of the service.

C. The feeder or service has overcurrent protection in accordance with sections 230-90 and 240-3 of the NEC.

(NOTE: Article 230-90 requires overload protection in each ungrounded conductor. Article 240-3 requires that conductors other than flexible cords and fixture wires be protected against overcurrent in accordance with their ampacities as specified in Tables 310-16 through 310-31 and all applicable notes to these tables.)

VII. Exceptions to the NEC requirements for support of flexible metal conduit

(NOTE: Refer to NEC Article 350-4.)

A. Where flexible metal conduit is fished

B. Lengths not exceeding 3 feet

C. Lengths not exceeding 6 feet from a fixture terminal connection to lighting fixtures

VIII. Steps for determining the number of conductors allowed in a conduit, based on cross sectional area

A. Determine size of existing conduit.

B. Determine number and size of existing conductors.

C. Find area of conduit or tubing using Table 4, Chapter 9 of the NEC.

D. Compute total area occupied by existing conductors based on Table 5, Chapter 9 of the NEC.

INFORMATION SHEET

E. Determine number of conductors that may be added.

EXAMPLE: An existing 1 inch conduit contains three #8 THHN conductors. Four #12 THW conductors need to be added to feed a new circuit.

1 inch conduit with over two conductors not lead covered has an area of .34 square inches (Table 4, Chapter 9)

#8 THHN has an area of .0471 sq. in. (Table 5, Chapter 9)

$$\begin{array}{l} .0471 \text{ sq. in.} \\ \underline{\times \quad 3} \\ .1413 \text{ sq. in.} \end{array}$$

#12 THW has an area of .0172 sq. in. (Table 5, Chapter 9)

$$\begin{array}{l} .0172 \text{ sq. in.} \\ \underline{\times \quad 4} \\ .0688 \text{ sq. in.} \end{array}$$

Total area required for conductors is:

$$\begin{array}{r} .0471 \\ \underline{+.0688} \\ .1159 \text{ sq. in.} \end{array}$$

.1159 is less than .34 therefore the four #12 THW conductors may be added.

EXISTING STRUCTURES
UNIT XVI

ASSIGNMENT SHEET #1 — DETERMINE THE NUMBER OF CONDUCTORS ALLOWED TO BE ADDED TO AN EXISTING CONDUIT

NAME ______________________________ SCORE ______________

Directions: Using the steps listed in Objective VIII of the Information Sheet and the NEC, determine if additional conductors may be added to a conduit if a new conduit is necessary. Show your calculations.

1. An existing 3/4" conduit contains three #10 THW conductors; you need to add three more #10 THW conductors.

2. A 1/2" conduit contains three #12 THHN conductors. Will four more #12 THHN conductors be allowed?

3. A 1 1/2" conduit contains three I/O THW conductors. Will three #6 THHN conductors be allowed?

EXISTING STRUCTURES
UNIT XVI

ANSWERS TO ASSIGNMENT SHEET #1

1. .21 sq. in. conduit area
   .0311 sq. in. #10 THW

   $$\begin{array}{r} .0311 \\ \underline{\times \quad 6} \\ .1866 \end{array}$$ sq. in.

   .1866 is less than .21; therefore, the additional wires are allowed.

2. .12 sq. in. conduit area
   .0117 sq. in. #12 THHN

   $$\begin{array}{r} .0117 \\ \underline{\times \quad 7} \\ .0819 \end{array}$$ sq. in.

   .0819 is less than .12; therefore, the additional wires are allowed.

3. .82 sq. in. conduit area
   .2367 sq. in. for I/O THW
   .0519 sq. in. for #6 THHN

   $$\begin{array}{r} .2367 \\ \underline{\times \quad 3} \\ .7101 \end{array}$$ sq. in. $$\begin{array}{r} .0519 \\ \underline{\times \quad 3} \\ .1557 \end{array}$$ sq. in.

   $$\begin{array}{r} .7101 \\ \underline{+.1557} \\ .8658 \end{array}$$ sq. in.

   .8658 is greater than .82; therefore, a new conduit must be run.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #1 — INSTALL A BOX WITH DRY WALL GRIPS IN A PLASTERBOARD WALL

A. Equipment and materials needed

1. Plasterboard wall
2. Box with plaster ears and dry wall grips

   (NOTE: Several forms of attaching devices are made for securing boxes of dry wall plasterboard.)

3. Pouch tools
4. ½" drill bit
5. Brace or drill motor and cord
6. Pencil
7. Keyhole saw
8. Safety glasses
9. Drop cloth
10. Duplex receptacle

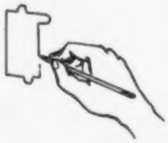
B. Procedure

(NOTE: Be sure that you are going to be able to get a cable to where the box is to be cut in before starting.)

1. Gather equipment and materials and put on safety glasses.
2. Mark box height on wall.
3. Pencil around the box. (Figure 1)

   (NOTE: Tap along the wall listening for hollow spaces or use a stud finder to make sure that a stud will not be in the cut out for the box.)

FIGURE 1

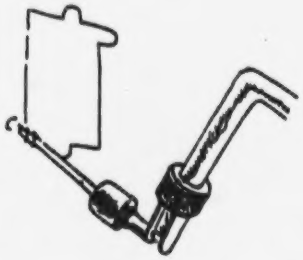


JOB SHEET #1

4. Place drop cloth below work area.

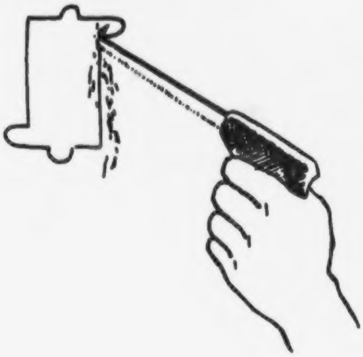
5. Drill holes in two of the corners. (Figure 2)

FIGURE 2



6. Saw along drawn lines. (Figure 3)

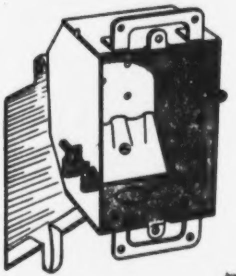
FIGURE 3



7. Fit box into opening. (Figure 4)

(NOTE: You may need to do some trimming. The plasterboard will chalk white places on the box in areas where trimming is needed.)

FIGURE 4



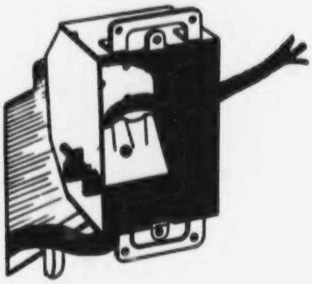
JOB SHEET #1

8. Remove box.

9. Insert conductors.

J. Replace box in opening. (Figure 5)

FIGURE 5



K. Secure box.

(NOTE: Tighten screw until box is secure.)

L. Pick up drop cloth.

M. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #2 — SECURE A BOX WITH DRY WALL SUPPORTS (BOXTINS)

A. Equipment and materials needed

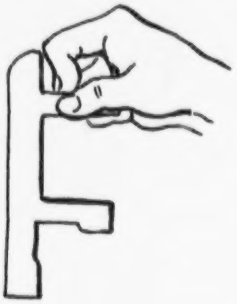
(NOTE: This job sheet deals only with the securing of boxes after the cable has been run and the opening cut.)

1. Dry wall box with ears
2. Drywall box supports (boxtins)
3. Opening in dry wall
4. Lineman's pliers

B. Procedure

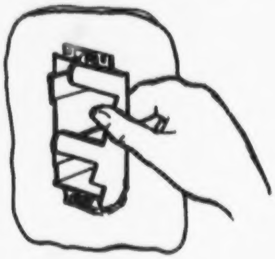
1. Place box in opening.
2. Grip box supports (boxtins) in one hand. (Figure 1)

FIGURE 1



3. Insert bottom of support beside box. (Figure 2)

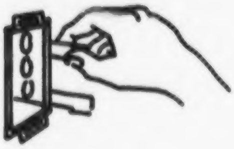
FIGURE 2



JOB SHEET #2

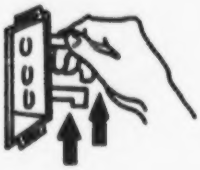
4. Push top of support in. (Figure 3)

FIGURE 3



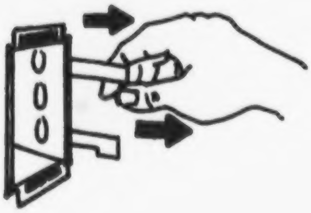
5. Raise support about ½". (Figure 4)

FIGURE 4



6. Apply outward pressure on support. (Figure 5)

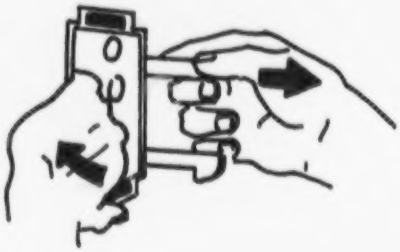
FIGURE 5



JOB SHEET #2

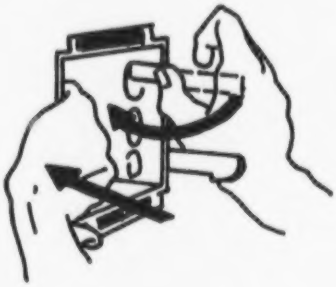
7. Put inward pressure on box with other hand. (Figure 6)

FIGURE 6



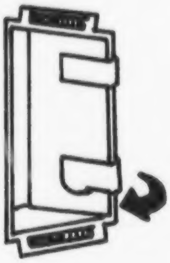
8. Bend tang over to secure box. (Figure 7)

FIGURE 7



9. Bend other tang. (Figure 8)

FIGURE 8

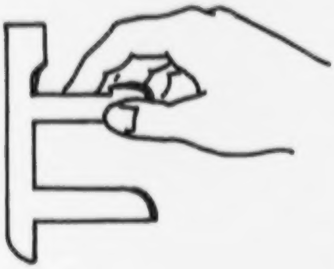


JOB SHEET #2

10. Grasp other support. (Figure 9)

    (NOTE: It may be inserted with the long spine in the opposite direction of the first.)

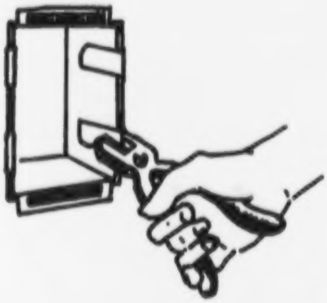
    FIGURE 9



11. Secure in wall using steps "C" through "I".

12. Pinch tangs with lineman's pliers. (Figure 10)

    FIGURE 10



13. Have instructor evaluate work.

14. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #3 — INSTALL A BOX IN A LATH AND PLASTER WALL

A. Equipment and materials needed

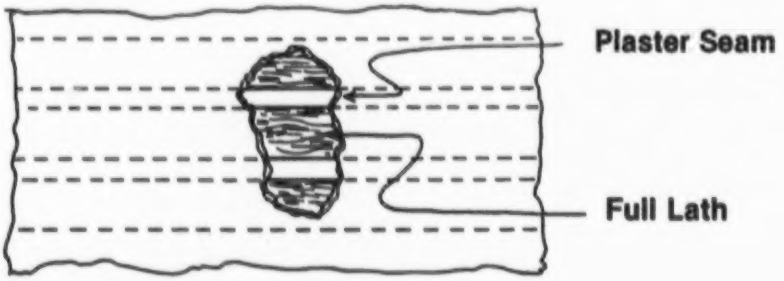
1. Lath and plaster wall
2. Box with plaster ears
3. Two #6 or #4 × ¾" metal tapping or wood screws
4. Pouch tools
5. Keyhole saw
6. Pencil
7. Safety glasses
8. Drop cloth

B. Procedure

(NOTE: Be sure that you are going to be able to get a cable to where the box is to be cut in before starting.)

1. Gather equipment and materials and put on safety glasses.
2. Mark box height on wall.
3. Place drop cloth below work area.
4. Punch a hole near your mark with a screwdriver.
5. Locate full lath. (Figure 1)

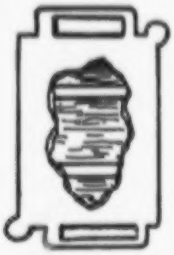
FIGURE 1



JOB SHEET #3

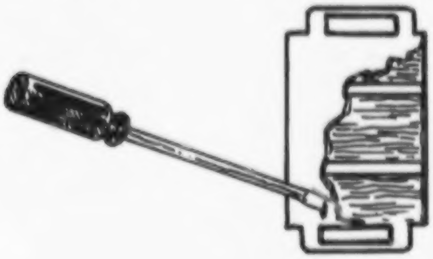
6. Pencil around box using full lath as center point. (Figure 2)

FIGURE 2



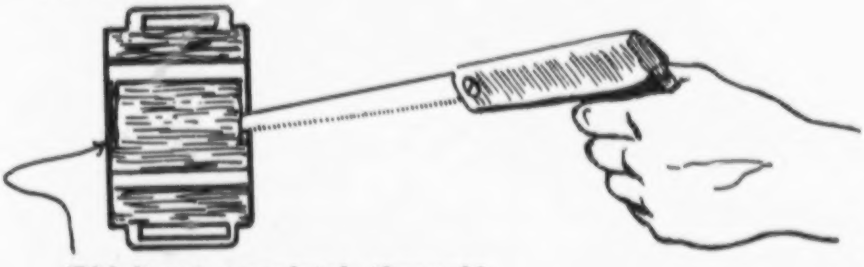
7. Break out plaster along penciled line with screwdriver. (Figure 3)

FIGURE 3



8. Cut center lath completely out. (Figure 4)

FIGURE 4



(Didn't cut completely through)

(NOTE: It will be easier if you don't cut completely through one side before starting on the other. Leaving a small connecting point stops a lot of vibration. Sometimes it may be necessary to wedge the lath with a screwdriver to eliminate vibration.)

JOB SHEET #3

9. Cut enough of top and bottom lath to accommodate box.

10. Install cable in box.

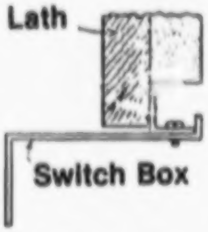
11. Place box in opening.

12. Secure with screws.

13. Reset plaster ears if plaster breaks from behind ears.

(NOTE: If the plaster is not solid enough to provide firm support, clean it out from behind ears. See Figure 5.)

FIGURE 5



14. Secure with screws. (Figures 6 and 7)

FIGURE 6

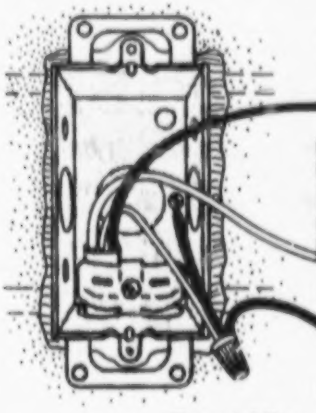
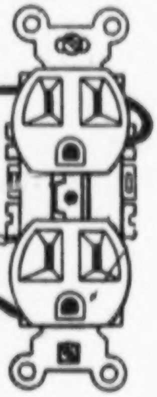


FIGURE 7



Front View

15. Install receptacle.

16. Pick up drop cloth.

17. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #4 — INSTALL A BOX IN A PANELED WALL

A. Equipment and materials needed

1. Paneled wall
2. Pouch tools
3. 1/2" drill bit
4. Brace or drill motor and cord
5. Keyhole saw
6. Pencil
7. Drop cloth
8. Switch box with ears
9. Four #6 × 3/4 metal tapping or woodscrews

   (NOTE: If plasterboard is behind the paneling you can use one of the forms of dry wall grips.)

10. Masking tape
11. Safety glasses
12. Portable GFI

B. Procedure

(NOTE: Be sure that you are going to be able to get a cable to where the box is to be cut in before starting.)

1. Gather equipment and material.
2. Mark box height on wall.
3. Pencil around box.

   (NOTE: Notice nail locations or use a stud finder or tap for hollow sounds to make sure you are in a hollow space.)

4. Put masking tape over lines and re-mark if not visible.

   (NOTE: This will keep wood from splintering while drilling and sawing.)

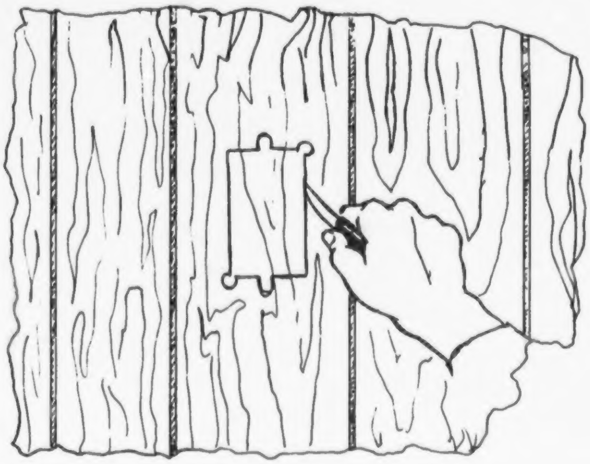
5. Place drop cloth below work area.

JOB SHEET #4

6. Cut along penciled lines with knife. (Figure 1)

   (NOTE: If you don't cut through the top layer of the paneling it will splinter out when you start sawing.)

   FIGURE 1



7. Drill holes in two corners of penciled in box.

   (NOTE: Be sure and plug cord into GFI if a drill motor is used.

8. Saw out opening.

   (NOTE: Saw inside of your knife cut to avoid splintering of the paneling.)

9. Fit box into opening.

   (NOTE: If you have to trim the opening use your knife instead of the saw to avoid splintering.)

10. Remove box.
11. Install cable.
12. Reinstall box in opening.
13. Secure box.
14. Remove masking tape.
15. Pick up drop cloth.
16. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #5 — INSTALL A BOX IN A CONCRETE BLOCK WALL

A. Equipment and materials needed

1. Pouch tools
2. Concrete block wall
3. Concrete chisel
4. Switch box with ears
5. Pencil
6. Mortar

   (NOTE: This can be a commercial pre-mix or sand and cement mixture you blend yourself.)

7. Wood scraps
8. Safety glasses

B. Procedure

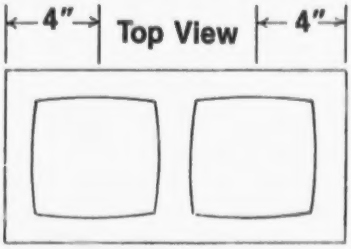
(NOTE: Be sure you will be able to get a cable to where the box will be cut in before starting.)

1. Gather equipment and materials and put on safety glasses.
2. Mark approximate box height.

   (NOTE: Make your mark in a mortar joint at the top or bottom edge of a block.)

3. Pencil around box.

   (NOTE: Make sure your box will be centered in a hollow space in the block. Four inches from either end should be a hollow space on an 8" × 8" × 16" block.)

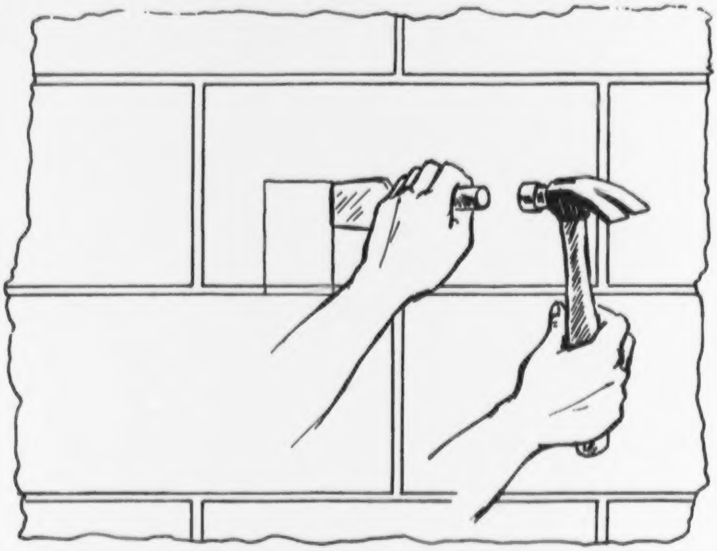


JOB SHEET #5

4. Tap chisel along pencil lines with hammer (Figure 1)

   (NOTE: This should be done until a groove approximately one sixteenth of an inch deep replaces your penciled outline.)

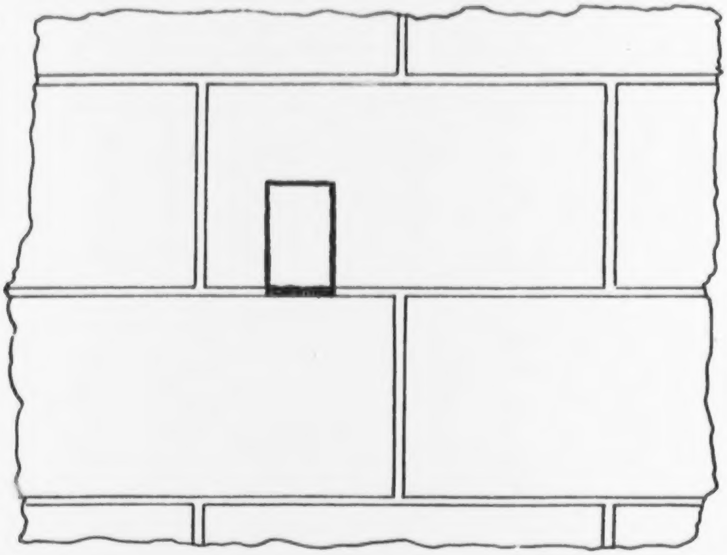
FIGURE 1



5. Knock mortar out along box outline (Figure 2)

   (NOTE: If mortar is difficult to remove, you can drill it out. Be sure and use portable GFI.)

FIGURE 2

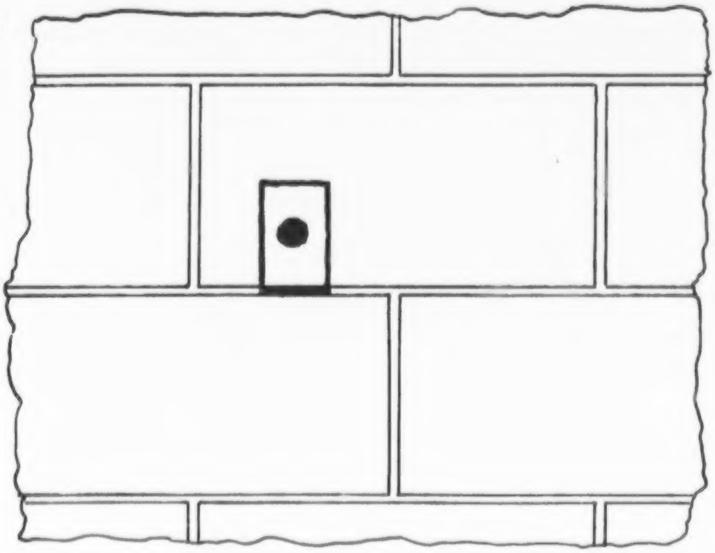


JOB SHEET #5

6. Tap center of box outline with hammer. (Figure 3)

   (NOTE: After several taps a hole will form.)

FIGURE 3



7. Gently tap from center hole towards the grooved box outline.

   (NOTE: The block should crack off at the groove. Don't get in a hurry. Slowly work around the groove until the opening is formed.)

8. Fit box into opening.

   (NOTE: The hole may have to be dressed with the chisel until the box fits.)

9. Remove box.

10. Install cable in box.

    (NOTE: You may have to enter the back of the box; in this event you'll need a 3/8" cable clamp.)

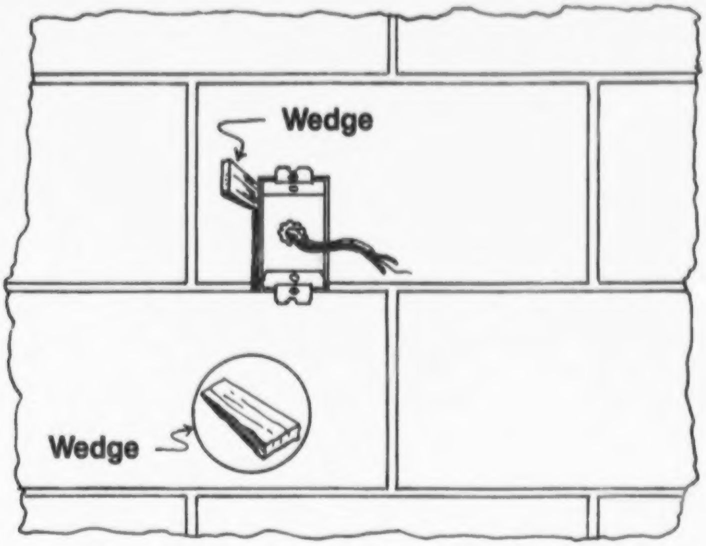
11. Reinstall box in opening.

JOB SHEET #5

12. Secure box with narrow wood wedges. (Figure 4)

    (NOTE: The wedges can be made by chipping at the end of a two by four with your hammer claws. Put one wedge at the top and one at the bottom in opposite corners.)

FIGURE 4



13. Flush off wood securing wedges.

    (NOTE: Even if box seems secure, you must use mortar or construction adhesive to finish the process.)

14. Mix up small amount of mortar.

15. Force mortar between box and opening in block.

16. Smooth out excess mortar.

17. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #6 — INSTALL A BOX IN A BRICK WALL

A. Equipment and materials needed

1. Brick wall
2. Pouch tools
3. 1/4" masonry bit

   (NOTE: The bit could be larger; however a larger bit will usually take more time to make the necessary penetrations.)

4. Drill motor and cord
5. Switch box with ears
6. 2 plastic anchors with appropriate bit and screws
7. Concrete chisel
8. Pencil
9. Mortar
10. 3/8" cable clamp
11. Portable GFI
12. Safety glasses

B. Procedure

(NOTE: Be sure you are going to be able to get a cable to where the box is to be cut in before starting.)

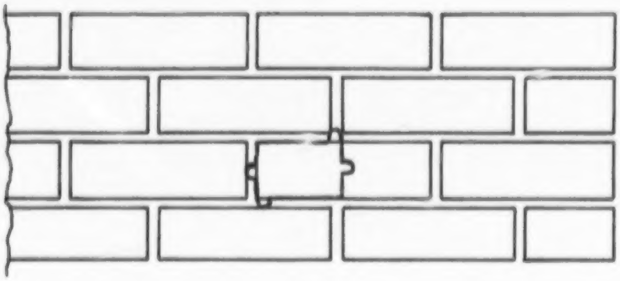
1. Gather equipment and materials and put on safety glasses.
2. Mark box height on wall.

JOB SHEET #6

3. Pencil around the box. (Figure 1)

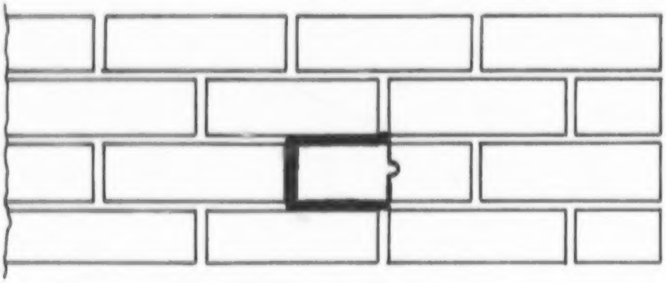
   (NOTE: Place the box horizontally so that only one cut is needed in a brick. If existing outlets are installed vertically, then this box should also be installed vertically.)

   FIGURE 1



4. Chisel the mortar from around your penciled in box. (Figure 2)

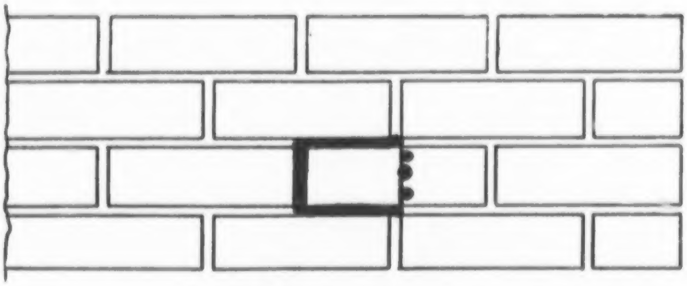
   FIGURE 2



5. Drill three or four holes along box outline in brick. (Figure 3)

   (NOTE: Be sure to use GFI with your power tools.)

   FIGURE 3



JOB SHEET #6

6. Chisel a groove between the drill holes.

   (NOTE: The brick may break while you are grooving it.)

7. Tap on the free end of the brick until it breaks.

   (NOTE: Do not push the brick bat back into the wall. Remove it from the wall when it breaks.)

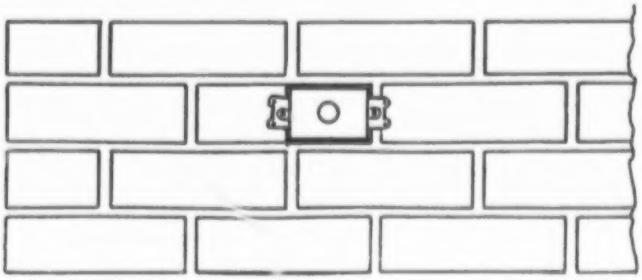
8. Fit box in opening.

   (NOTE: You may have to dress the hole up with the concrete chisel.)

9. Mark holes in plaster ears for anchors. (Figure 4)

   (NOTE: One in each ear will be sufficient.)

FIGURE 4



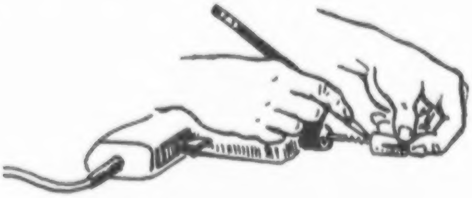
10. Remove box.

11. Install anchors.

    a. Measure anchor on drill bit. (Figure 5)

       (NOTE: This tells you when to stop so your anchor will bottom out.)

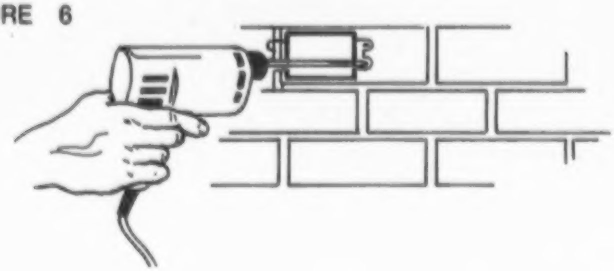
FIGURE 5



JOB SHEET #6

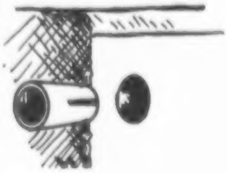
b. Drill hole to marked depth. (Figure 6)

FIGURE 6



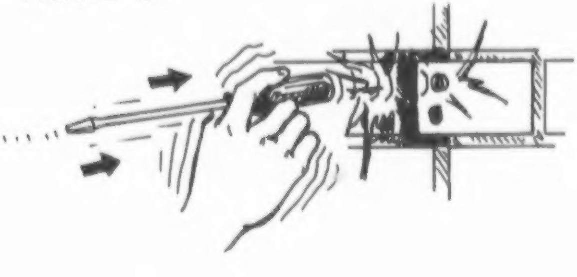
c. Insert small end of anchor in hole. (Figure 7)

FIGURE 7



d. Tap with screwdriver butt to seat. (Figure 8)

FIGURE 8



JOB SHEET #6

12. Replace cable in box.
13. Secure cable clamp.
14. Insert box in opening.
15. Install screws in anchor.
16. Secure box.
17. Mix mortar.
18. Fill joints around box.
19. Smooth joints with finger.
20. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #7 — INSTALL A BOX IN A CEILING WITH AN ACCESSIBLE ATTIC

A. Equipment and materials needed

1. Pouch tools
2. Keyhole saw
3. Octagon box
4. Bar hanger
5. Pencil
6. Drop cloth
7. Step ladder

   (NOTE: Remember to be safety conscious when working at all times, and remember the rules for ladder use.)

8. Safety glasses
9. ½" drill bit
10. Brace or drill motor and cord
11. 2 single or plasterboard nails
12. Trouble light and bulb
13. Portable GFI

B. Procedure

(NOTE: Be sure you can get a cable to where you are going to cut the box in.)

1. Gather equipment and materials and put on safety glasses.
2. Set up ladder.
3. Place drop cloth under work area.
4. Mark box location on ceiling.
5. Pencil around the box.

   (NOTE: Be sure there is not a ceiling joist above where you plan on cutting the box in.)

JOB SHEET #7

6. Drill a hole in the corner of box outline.

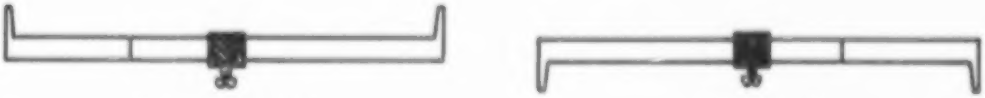
7. Saw out the box opening.

   (NOTE: If the ceiling is lath, chip the plaster off inside your outline before you saw the lath.)

8. Attach bar to box. (Figure 1)

   (NOTE: Reverse the bar so the nail slots are upward for easy nailing. Installation must comply with NEC Article 370-13.)

FIGURE 1



Reversed bar

Standard

9. Move ladder to attic access hole.

10. Plug in drop light.

11. Go into attic with pouch tools, nails, box, and trouble light.

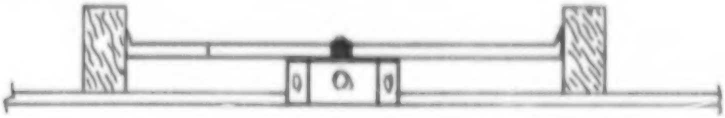
12. Walk on ceiling joists over to box opening.

13. Position box in hole.

14. Nail bar hanger between joists. (Figure 2)

    (NOTE: Be sure box is flush with ceiling.)

FIGURE 2



JOB SHEET #7

15. Insert cable in box.
16. Gather tools and light.
17. Get down from attic.
18. Reposition ladder.
19. Tighten cable clamp and box support screw.
20. Pick up drop cloth.
21. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #8 — INSTALL CABLE BETWEEN AN EXISTING BOX AND A NEWLY INSTALLED BOX HORIZONTALLY ALONG A WALL IN A CHANNEL BEHIND BASEBOARD

A. Equipment and materials needed

(NOTE: Check with local code enforcing agency on acceptable installation methods before starting.)

1. Pouch tools
2. Keyhole saw
3. 12-2G cable
4. Suitable box with some type of dry wall fasteners
5. Drop cloth
6. Whisk broom
7. Touch up materials

   (NOTE: This includes paint and brush if needed.)
8. Safety glasses
9. Chisel
10. Flat bar

B. Procedure

(NOTE: Turn off circuit and check it before starting.)

1. Put on safety glasses.
2. Gather equipment and materials.
3. Cut in new box.

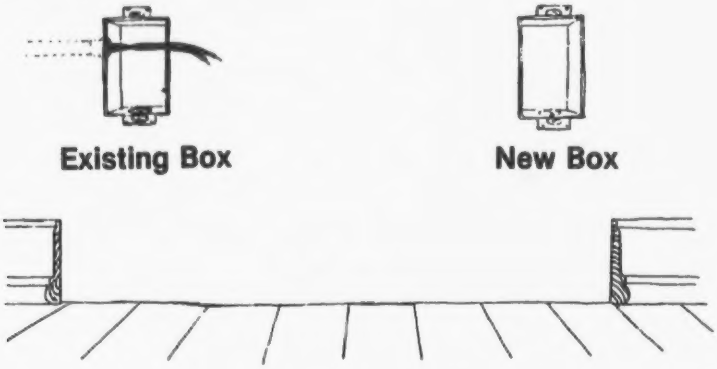
   (NOTE: Be sure and consider wall covering materials before making your opening.)

JOB SHEET #8

4. Remove baseboard between boxes. (Figure 1)

   (NOTE: The illustrations will show boxes on the same wall. Baseboard will have to be removed from two walls if you go around the corner for the new box.)

   FIGURE 1



   a. Pry baseboard out with flat bar.

   b. Start at one end and work evenly along baseboard.

   c. Cut nails flush to baseboard.

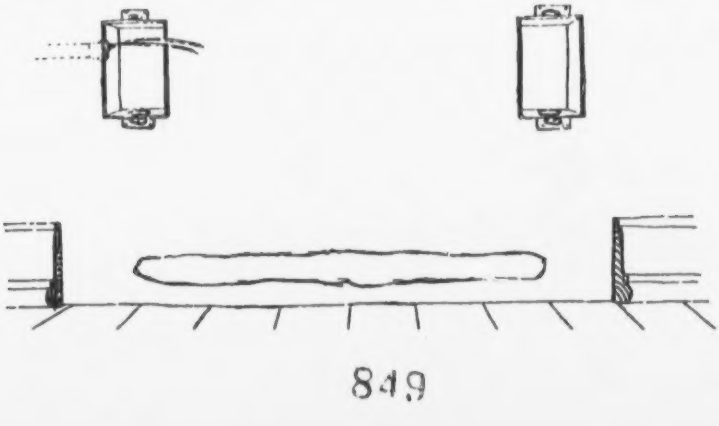
   d. Lay baseboard aside until needed.

5. Place drop cloth along floor line.

6. Form channel with hammer and chisel. (Figure 2)

   (NOTE: Be sure your channel is behind the baseboard. Most older houses have a sufficiently tall baseboard.)

   FIGURE 2

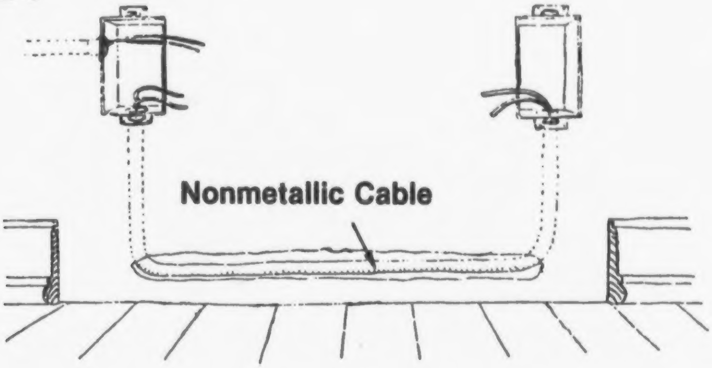


JOB SHEET #8

7. Install cable. (Figure 3)

(NOTE: You may have to bore a hole through a piece of lath or through the top edge of a bottom plate.)

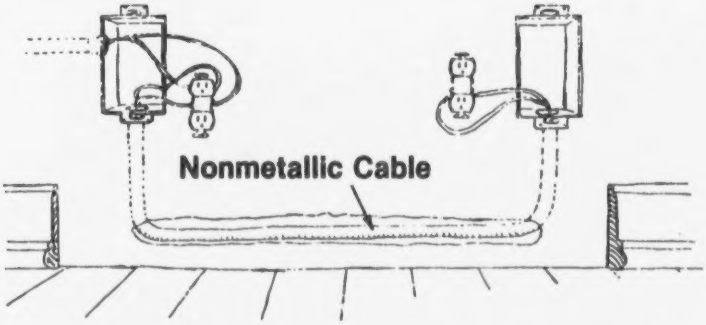
FIGURE 3


Nonmetallic Cable

8. Install devices. (Figure 4)

(NOTE: Refer to NEC Article 300-13 for requirements of conductor continuity.)

FIGURE 4


Nonmetallic Cable

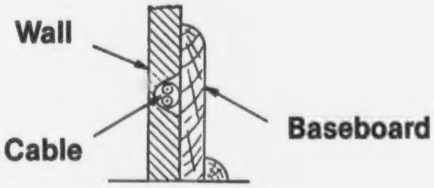
JOB SHEET #8

9. Replace baseboard.

   a. Check cable fit. (Figure 5)

      (NOTE: The baseboard should fit back flat against the wall.)

      FIGURE 5



   b. Renail baseboard.

      (CAUTION: Care should be taken to insure nails do not puncture cable.)

10. Touch-up baseboard.

    (NOTE: The homeowner may have some of the original paint.)

11. Pick up drop cloth.

12. Clean work area and put away all equipment and materials.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #9 — INSTALL CABLE BETWEEN AN EXISTING BOX AND A NEWLY INSTALLED BOX USING AN UNDERFLOOR CRAWL SPACE

(NOTE: This procedure requires two people, one above and one in the crawl space.)

A. Equipment and materials needed

1. Pouch tools
2. Drop light and cord
3. Drill motor
4. Ship auger bit
5. Suitable box with dry wall fasteners
6. 12-2G cable
7. Staples
8. Drop cloth
9. Fish wire
10. String
11. Tape
12. Portable GFI
13. Volt ohmmeter
14. Safety glasses

B. Procedure

(NOTE: Turn off and check circuit before starting. Be sure that there is no space under the floor to work before this method is used.)

1. Put on safety glasses.
2. Gather equipment and materials.
3. Cut in new box.
4. Remove existing device.
5. Locate crawl space access hole.
6. Connect GFI to outlet and cord to GFI.

JOB SHEET #9

7. Locate place to drill.

   (NOTE: A nail can be driven down through the floor or measurements can be taken from above and transferred to below.)

8. Drill holes. (Figures 1 and 2)

   (NOTE: In some instances you may have to remove baseboard and drill down on outside walls. It is usually better however to drill from below.)

FIGURE 1

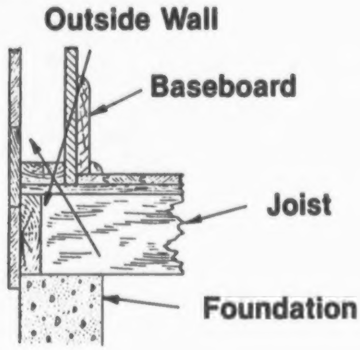
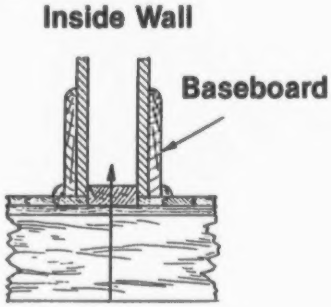

Outside Wall
Baseboard
Joist
Foundation

FIGURE 2


Inside Wall
Baseboard

9. Make opening at existing box for cable.

   a. Remove a knockout from box.

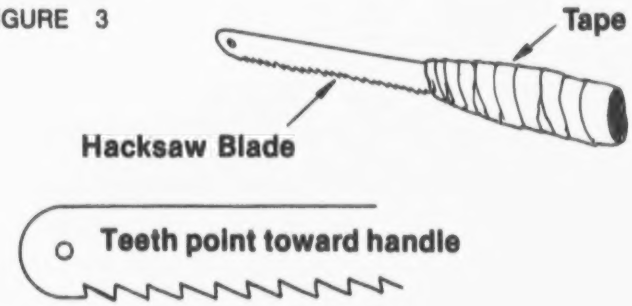
      (NOTE: If a knockout cannot be removed, remove the box.)

   b. Remove box if necessary.

      1) Insert saw between box and stud.

         (NOTE: A saw can be constructed with an old or broken hacksaw blade. See Figure 3.)

FIGURE 3


Tape
Hacksaw Blade
Teeth point toward handle

JOB SHEET #9

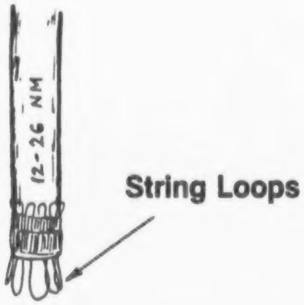
2) Cut nails.

3) Move box out of way.

10. Fish wire through drilled hole.

    a. Tape string in loops to cable. (Figure 4)

    FIGURE 4

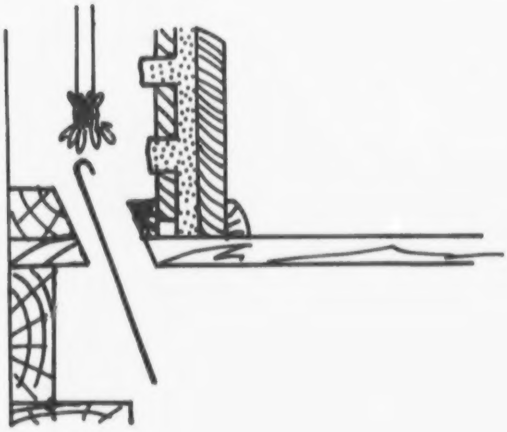


    b. Push cable in opening.

    (NOTE: Insulation in walls may make it more difficult to fish the wires.)

    c. Push fish wire with loop up from bottom and wiggle to hook loops. (Figure 5)

    FIGURE 5



JOB SHEET #9

   d. Pull cable through hole while being fed from above.

      (NOTE: This effort needs to be coordinated between the people working. Signals such as two quick jerks for more cable to be fed should be established.)

   e. Pull cable over to other hole.

   f. Push through hole and fish from above.

11. Staple cable as code requires.

12. Install new box.

    (NOTE: Install original existing box if it was removed.)

13. Install devices.

14. Activate circuit and test it.

15. Clean work area and put away all equipment and materials.

16. Reseal crawl space access hole.

EXISTING STRUCTURES
UNIT XVI

JOB SHEET #10 — INSTALL CABLE BETWEEN AN EXISTING BOX AND A NEWLY INSTALLED BOX USING ATTIC SPACE

(NOTE: This job requires the coordinated effort of two people.)

A. Equipment and materials needed

1. Pouch tools
2. Drop light and cord
3. Drill motor
4. Ship auger bit
5. Suitable box with dry wall fasteners
6. 12-2G cable
7. Staples
8. Drop cloth
9. Drop chain
10. Steel fish tape
11. Volt ohmmeter
12. Ladder

    (NOTE: Ladder should be tall enough to allow easy entry into attic.)

13. Tape
14. Safety glasses
15. Dust mask
16. Portable GFI

B. Procedure

(NOTE: Be sure and turn off and check circuit before starting.)

1. Put on safety glasses.
2. Gather equipment and materials.
3. Put down drop cloth.

JOB SHEET #10

4. Remove existing device.
5. Plug in GFI and drop light.
6. Set up ladder at access hole.
7. Put the following materials up in the attic:
    a. Pouch tools
    b. Drop chain
    c. Drop light
    d. Drill motor and bit
    e. Distances measured for drilling written on paper
8. Put on dust mask.
9. Enter the attic carefully.

    (NOTE: When traveling across the attic be sure and walk on ceiling joists. You may have to brush insulation aside as you walk to locate them.)

10. Locate spot to drill.
11. Drill hole.

    (NOTE: On inside walls drilling shoud be no problem. On ouside walls the pitch of the roof may affect how you get through or around the top plate.)

12. Drop one end of chain in the hole.

    (NOTE: You can stick a screwdriver through one end of the chain to be sure it does not slip from your hand and fall through the hole. Insulated exterior walls may require the use of a solid wire or fish tape.)

13. Shake chain till located below through opening.
14. Cut in new box.

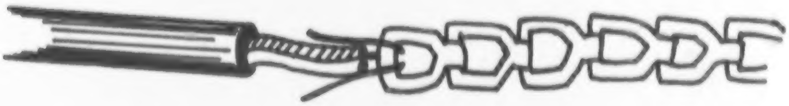
    (NOTE: Measurements should be taken carefully so the holes bored from the attic are in the right stud space.)

15. Pull end of chain through hole.
16. Fasten chain to cable.
    a. Strip about 6" of outer cable sheath.
    b. Strip about 2" of insulation from conductors.

JOB SHEET #10

c. Insert conductors in chain loops and bend over. (Figure 1)

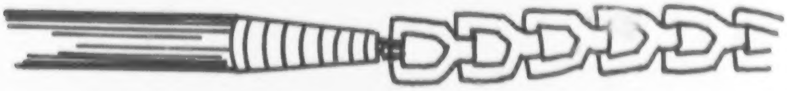
FIGURE 1



d. Tape the connecting joint back over the cable. (Figure 2)

(NOTE: A smooth joint allows the cable to pass through the drilled hole without hanging up.)

FIGURE 2



17. Pull up into attic.

(NOTE: A couple of tugs on the chain can signal the attic man to start pulling up. Cable should be pulled in two or three feet lifts to allow feed man to straighten cable as it is fed.)

18. Pull enough cable to go over to next hole and down to existing box.

(NOTE: Pull plenty, because you can refeed excess back down to new box before it is cut.)

JOB SHEET #10

19. Drill hole above existing outlet.

    (NOTE: Sometimes a hole already exists where another cable goes down. Use this space if large enough.)

20. Drop chain into hole.

21. Fish chain out of existing box.

    (NOTE: If a knockout will not allow you to fish chain, cut nails and remove box.)

22. Pull out enough cable for installation.

23. Pull excess back through new hole.

24. Staple cable in attic.

25. Remove equipment and materials from attic.

    (NOTE: Ground man should be waiting to receive materials as they are handed down.)

26. Replace attic access cover.

27. Install devices.

28. Activate circuit.

29. Test devices.

30. Clean work area and put away equipment and materials.

BW-957

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #1 — INSTALL A BOX WITH DRY WALL GRIPS IN A PLASTERBOARD WALL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Correctly marked box on wall.	______	______
3. Protected work area with drop cloth.	______	______
4. Installed box on wall.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Opening located correctly	4	3	2	1
Opening sized correctly	4	3	2	1
Conductors installed correctly	4	3	2	1
Box installed level	4	3	2	1
Box installed flush	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #2 — SECURE A BOX WITH DRY WALL SUPPORTS (BOXTINS)

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Inserted box supports correctly.	______	______
3. Used proper technique for holding (box) and bending (supports).	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Box installed level	4	3	2	1
Box installed flush	4	3	2	1
Box installed securely	4	3	2	1
Box supports flat inside box	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #3 — INSTALL A BOX IN A LATH AND PLASTER WALL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Protected work area with drop cloth.	______	______
3. Marked hole at proper location.	______	______
4. Used caution in breaking out plaster.	______	______
5. Installed cable and box in opening and secured with screws.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Box opening located correctly	4	3	2	1
Box opening sized correctly	4	3	2	1
Box installed level	4	3	2	1
Box installed flush	4	3	2	1
Conductors installed correctly	4	3	2	1
Box installed securely	4	3	2	1
Device installed correctly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #4 — INSTALL A BOX IN A PANELED WALL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Protected work area with drop cloth.	______	______
3. Marked box opening correctly.	______	______
4. Protected box opening edges with masking tape.	______	______
5. Installed cable and box correctly.	______	______
6. Secured box.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Box opening located correctly	4	3	2	1
Box opening sized correctly	4	3	2	1
Box installed level	4	3	2	1
Box installed flush	4	3	2	1
Cable installed correctly	4	3	2	1
Box installed securely	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #5 — INSTALL A BOX IN A CONCRETE BLOCK WALL

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUAT[illegible]OTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Protected work area with drop cloth.	______	______
3. Marked box opening correctly.	______	______
4. Removed mortar and formed box opening.	______	______
5. Installed cable and box correctly.	______	______
6. Secured box with wood wedges.	______	______
7. Inserted mortar between box and opening in block and removed excess mortar.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #5 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Box opening located correctly	4	3	2	1
Box opening sized correctly	4	3	2	1
Box installed level	4	3	2	1
Box installed flush	4	3	2	1
Cable installed correctly	4	3	2	1
Box installed securely	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #6 — INSTALL A BOX IN A BRICK WALL

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Protected work area with drop cloth.	______	______
3.	Marked box opening correctly.	______	______
4.	Removed mortar and brick to form opening.	______	______
5.	Installed anchors.	______	______
6.	Installed cable and box correctly.	______	______
7.	Secured box.	______	______
8.	Filled joints around box with mortar and smoothed with finger.	______	______
9.	Checked in/put away tools and materials.	______	______
10.	Cleaned the work area.	______	______
11.	Used proper tools correctly.	______	______
12.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13.	Practiced safety rules throughout procedure.	______	______
14.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #6 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Box opening located correctly	4	3	2	1
Box opening sized correctly	4	3	2	1
Box installed level	4	3	2	1
Box installed flush	4	3	2	1
Cable installed correctly	4	3	2	1
Box installed securely	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #7 — INSTALL A BOX IN A CEILING WITH AN ACCESSIBLE ATTIC

STUDENT'S NAME ______________________________ DATE ______________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Protected work area with drop cloth.	______	______
3. Marked box opening at correct location.	______	______
4. Installed box on bar hanger properly.	______	______
5. Installed box on bar hanger securely.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #7 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Box opening located correctly	4	3	2	1
Box opening sized correctly	4	3	2	1
Box installed flush	4	3	2	1
Cable installed correctly	4	3	2	1
Box installed securely	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

BW-971

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #8 — INSTALL CABLE BETWEEN AN EXISTING BOX AND A NEWLY INSTALLED BOX HORIZONTALLY ALONG A WALL IN A CHANNEL BEHIND BASEBOARD

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Removed baseboard correctly.	______	______
3. Protected work area with drop cloth.	______	______
4. Cut channel in stud correctly.	______	______
5. Installed cable and devices correctly.	______	______
6. Replaced and touched-up baseboard.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #8 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Box located correctly	4	3	2	1
Box installed flush	4	3	2	1
Cable installed correctly	4	3	2	1
Box installed securely	4	3	2	1
Baseboard reinstalled correctly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #9 — INSTALL CABLE BETWEEN AN EXISTING BOX AND A NEWLY INSTALLED BOX USING AN UNDERFLOOR CRAWL SPACE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Located and drilled hole in wall.	______	______
3. Protected work area with drop cloth.	______	______
4. Caution used in drilling to prevent damage to existing wall coverings (finished walls).	______	______
5. Pulled cable through drilled hole.	______	______
6. Stapled cable as required by code.	______	______
7. Installed new box and devices correctly.	______	______
8. Activated and tested circuit.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #9 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
New box installed correctly	4	3	2	1
Cable installed correctly	4	3	2	1
Cable supported correctly	4	3	2	1
Existing box re-installed correctly	4	3	2	1
Devices installed correctly	4	3	2	1
Activated and tested circuit	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

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EXISTING STRUCTURES
UNIT XVI

PRACTICAL TEST
JOB SHEET #10 — INSTALL CABLE BETWEEN AN EXISTING BOX AND A NEWLY INSTALLED BOX USING ATTIC SPACE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Located and drilled hole in wall.	______	______
3.	Protected work area with drop cloth.	______	______
4.	Caution used in drilling to prevent damage to existing wall coverings.	______	______
5.	Caution used in pulling cable.	______	______
6.	Cable stapled in attic.	______	______
7.	Installed new box and devices correctly.	______	______
8.	Activated and tested circuit.	______	______
9.	Checked in/put away tools and materials.	______	______
10.	Cleaned the work area.	______	______
11.	Used proper tools correctly.	______	______
12.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13.	Practiced safety rules throughout procedure.	______	______
14.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #10 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
New box installed correctly	4	3	2	1
Cable installed correctly	4	3	2	1
Cable supported correctly	4	3	2	1
Existing box re-installed correctly	4	3	2	1
Devices installed correctly	4	3	2	1
Activated and tested circuit	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
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(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

EXISTING STRUCTURES
UNIT XVI

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right with their correct definitions.

_____a. Groove formed in materials

_____b. Establishing a connection between two points so a cable can be installed

_____c. Length of wire with a hook formed in one end to catch materials being fished in a space

_____d. Working space underneath the house

_____e. Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

_____f. Flat sheets used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

_____g. Cloth used to catch falling debris from cutting or chipping work

_____h. Compass type tool which uses a magnet to find nails and thus indicate stud locations

_____i. Piece of a brick

_____j. Area in square inches allowed in a conduit or tubing; area required for conductors in a conduit or tubing

_____k. Short length of small chain used to pull conductors or flexible conduit through an enclosed space or wall cavity

_____l. Usually a vertical space between two floors, dedicated for the running of pipes and conduits between floors

1. Brick bat
2. Channel
3. Cross sectional area
4. Drop chain
5. Drop cloth
6. Fish
7. Fish wire
8. Lath and plaster
9. Pipe chase
10. Plasterboard
11. Stud finder
12. Underfloor crawl space

TEST

2. Identify the construction members common in existing structures shown in the two illustrations below.

______a. ______________________________

______b. ______________________________

______c. ______________________________

______d. ______________________________

______e. ______________________________

______f. ______________________________

______g. ______________________________

______h. ______________________________

______i. ______________________________

______j. ______________________________

______k. ______________________________

______l. ______________________________

______m. ______________________________

______n. ______________________________

______o. ______________________________

______p. ______________________________

______q. ______________________________

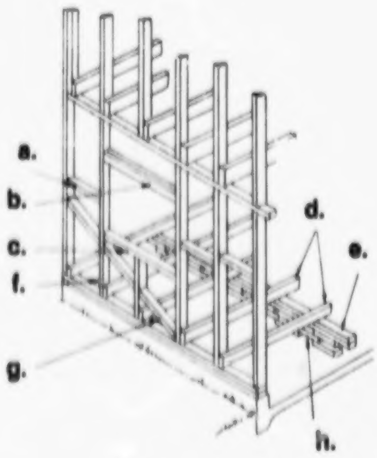
______r. ______________________________

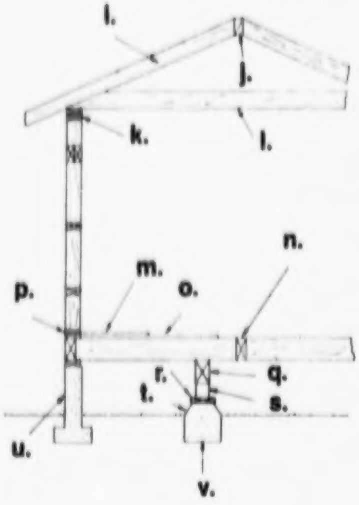
______s. ______________________________

______t. ______________________________

______u. ______________________________

______v. ______________________________

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TEST

3. List four common routes for new cable installations in existing structures.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

4. Complete the following list of possible methods for getting cable through or around construction members by inserting the words that best complete the list.

   a. Top plates

      1) ______________ drilling

      2) ______________ drilling

      3) Lifting a ______________ and drilling

      4) Over ______________ ______________ and back through insulation board inside eave

   b. Bottom plates (sole plate)

      1) ______________ drilling behind baseboard

      2) ______________ drilling

   c. Fire blocks

      1) Lifting shingle and ______________ drilling through block with extension

      2) Top drilling with door trim and baseboard ______________

      3) Top drilling and ______________ past

5. List five wall or ceiling compositions that may be found in an existing structure.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

TEST

6. Complete the following list of statements concerning conditions for using the optional calculations for additional loads to existing installations by inserting the word that best completes each statement.

   a. The maximum demand data is available in KVA for a minimum of a ____________ period.

   b. The existing demand at 125 percent plus the new load does not exceed the ampacity of the feeders or ____________ of the service.

   c. The feeder or service has ____________ in accordance with sections 230-90 and 240-3 of the NEC.

7. List two exceptions to the NEC requirements for support of flexible metal conduit.

   a. ____

   ____

   ____

   b. ____

   ____

   ____

8. Arrange in order the steps for determining the number of conductors allowed in a conduit, based on cross-sectional area by numbering from 1 to 5.

   _____a. Compute total area occupied by existing conductors based on Table 5, Chapter 9 of the NEC.

   _____b. Determine size of existing conduit.

   _____c. Determine number of conductors that may be added.

   _____d. Find area of conduit or tubing using Table 4, Chapter 9 of the NEC.

   _____e. Determine number and size of existing conductors.

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

9. Determine the number of conductors allowed to be added to an existing conduit. (Assignment Sheet #1)

10. Demonstrate the ability to:

    a. Install a box with dry wall grips in a plaster wall. (Job Sheet #1)

    b. Secure a box with dry wall supports (boxtins). (Job Sheet #2)

    c. Install a box in a lath and plaster wall. (Job Sheet #3)

    d. Install a box in a paneled wall. (Job Sheet #4)

    e. Install a box in a concrete block wall. (Job Sheet #5)

    f. Install a box in a brick wall. (Job Sheet #6)

    g. Install a box in a ceiling with an accessible attic. (Job Sheet #7)

    h. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind a baseboard. (Job Sheet #8)

    i. Install cable between an existing box and a newly installed box using an underfloor crawl space. (Job Sheet #9)

    j. Install cable between an existing box and a newly installed box using an accessible attic space. (Job Sheet #10)

EXISTING STRUCTURES
UNIT XVI

ANSWERS TO TEST

1.
   - a. 2
   - b. 6
   - c. 7
   - d. 12
   - e. 8
   - f. 10
   - g. 5
   - h. 11
   - i. 1
   - j. 3
   - k. 4
   - l. 9

2.
   - a. Fire block
   - b. Header
   - c. Sill
   - d. First floor joists
   - e. Plate
   - f. Stud
   - g. Brace
   - h. Sleeper wall
   - i. Rafter
   - j. Ridge board
   - k. Top plate
   - l. Ceiling joists
   - m. Floor board
   - n. Bridging
   - o. Sub floor
   - p. Bottom plate (sole plate)
   - q. Girder
   - r. Pier block
   - s. Girder post
   - t. Pier
   - u. Foundation wall
   - v. Footing

3.
   - a. Vertically in a wall
   - b. Horizontally in a channel behind baseboard
   - c. Horizontally in underfloor crawl space
   - d. Horizontally in an attic

4.
   - a.
     - 1) Straight
     - 2) Angle
     - 3) Shingle
     - 4) Top plate
   - b.
     - 1) Top
     - 2) Bottom
   - c.
     - 1) Top
     - 2) Removal
     - 3) Channeling

5.
   - a. Plasterboard
   - b. Lath and plaster
   - c. Paneling
   - d. Concrete block
   - e. Brick

ANSWERS TO TEST

6. a. One year
   b. Rating
   c. Overcurrent protection

7. Any two of the following:

   a. Where flexible metal conduit is fished
   b. Lengths not exceeding three feet
   c. Lengths not exceeding six feet from a fixture terminal connection to lighting fixtures

8. a. 4
   b. 1
   c. 5
   d. 3
   e. 2

9. Evaluated to the satisfaction of the instructor

10. Performance skills evaluated to the satisfaction of the instructor